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PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XVIII.

PUBLISHED QUARTERLY BY THE INSTITUTE.

ANNAPOLIS, MD.

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EDITED BY H. G. DRESEL.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE DRIGGS-SCHROEDER SYSTEM OF RAPID-FIRE GUNS.

By Lieut. W. H. Driggs, U. S. Navy.

Having been requested by the Naval Institute to contribute an rticle under the above title, I have compiled such data and records s may be of interest to its readers. It has been my intention to void, as far as possible, drawing any comparisons between this and ny other special system. As this publication circulates mainly nong men familiar with the results obtained from other guns of this ss, comparisons can be easily made from the data here given. It may fairly be said that the rapid-fire gun is a new improvement ordnance, as the guns ordered for the Chicago, Boston, Atlanta, and lphin were the first ordered by any government. Other nations soon lowed, and some had guns of this class actually in service before the ited States, owing to the fact that these ships were not ready to eive them for some time after the order was placed. From that to this the importance of this class of ordnance has gradually ased, and is likely to increase still further. From being present the secondary batteries it has found its way into the main

battery, and its caliber has been expanded from that of the 6-pounder to that of the 100-pounder.

To discuss the advantages of this class of ordnance in general would occupy more space than allowed to an article of this kind. I will therefore confine myself to describing the particular design of the Driggs-Schroeder.

At the time this gun was designed there was no place in the country where the Navy could obtain ordnance of this type. Even had the Department been inclined to purchase its guns from foreign countries, Congress effectually forestalled this by an act requiring the new ships to be throughout of domestic manufacture. There was, therefore, no course open except to induce manufacturers to start the building of these guns in the United States.

As the most successful gun of that day was the Hotchkiss, that company was offered an order for some 94 guns and a considerable amount of ammunition to induce them to build in this country. This order was accepted and the manufacture of the guns placed in the hands of the Pratt & Whitney Co., of Hartford, the ammunition being made by the Winchester Arms Co., of New Haven. About the time this order was placed with the Hotchkiss Co., an experimental 3-pdr. Driggs-Schroeder gun was made and submitted for trial at Annapolis. The results were all that had been anticipated, but the authorities hesitated to endorse the system until after the successful trial of a larger caliber. A 6-pounder was therefore built, and after successful tests, during which some 150 rounds were fired, under all conditions of service, an order was placed with the Driggs Ordnance Co. (which had been organized after the trial of the experimental 3-pdr.) for 20 guns (10 3-pounders and 10 6-pounders). This order was soon followed by an order for 30 more 6-pounders, on condition that the first gun delivered under the first order should pass a successful test of 200 rounds in 4 consecutive hours. This having been accomplished without any failure whatever, an order was placed with the Driggs Ordnance Co. for 75 additional 6-pounder guns. The experimental 6-pounder, after passing through the tests at Annapolis, was sent to Bridgeport for testing ammunition, and has now fired upwards of 400 rounds, without having any repairs whatever put upon the mechanism. The other 6-pounder gun tested at Annapolis, as mentioned above, has now fired about 350 rounds. No repairs have been put upon it, except the replacing of a small spring in the handle, which was injured in transporting the gun.

A 3-pounder gun has just passed through a very severe trial in England, conducted by the English government. In the preliminary test for strength, etc., the pressures and velocities reached were as follows:

Vel.	2005 f. s.	Pressure	12.8 tons.
"	2089 "	"	19.7 "
"	not taken	"	16.3 "
"	2121 "	"	16.7 "
"	2142 "	"	18.8 "
"	2165 "	"	19.2 "

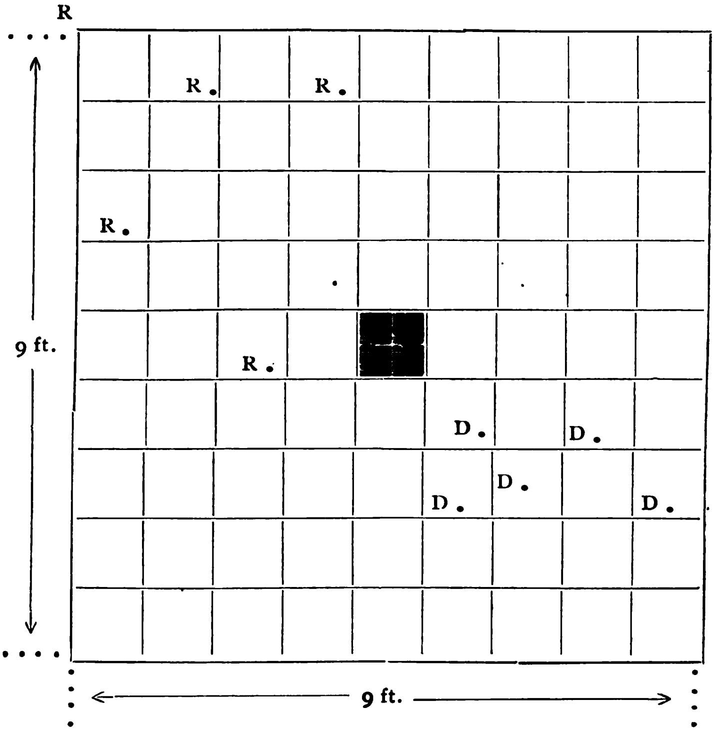
The main object of this part of the trial being for strength of gun, the powder charge was set to produce high pressures without regard to velocities. With suitable powder, the gun will give 2100 f. s. with a pressure under 15 tons. The breech-closure worked smoothly throughout. Tests were then made to see the effect of defective ammunition. For this purpose eight split cases and three pierced primers were the results out of 20 rounds. We believe this is the most severe test a gun of this class has ever been put to, but it can be said also to the credit of the piece, that with the exception of one misfire (which occurred after one of the blow-backs through the primer, and this cap was exploded on second trial), that the gun worked perfectly throughout. We mention this test particularly, as rivals have claimed that with blow-backs or high pressures the breech-block will stick. Four Driggs-Schroeder guns have been subjected to official tests, all of which have been satisfactory, and in no instance has the breech mechanism stuck.

During the last test in England a 3-pounder Driggs-Schroeder was brought in competition with a 3-pounder of a different system. The competition was on velocity, accuracy and jump. The velocities were as follows on first series:

Driggs-Schroeder.		Rival Gun.	
I. V.	1859 f. s.	I. V.	1843 f. s.
"	1856 "	"	1848 "
"	1893 "	"	1840 "
"	1861 "	"	1844 "
"	1900 "	"	1820 "
Mean	$1873\frac{4}{5}$ "	Mean	1839 "

The test for accuracy consisted of five rounds each at a target 9 feet square, distant 500 yards.

TARGET.



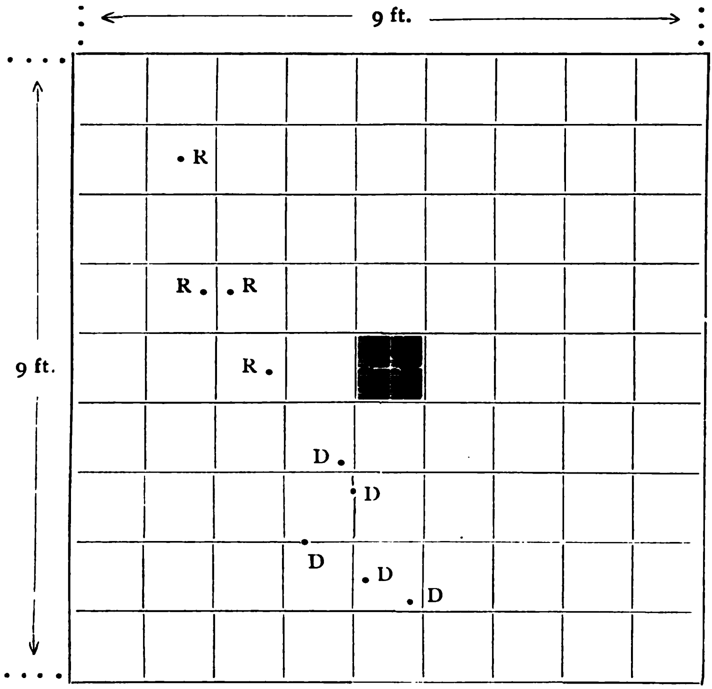
R = Rival gun. D = Driggs-Schroeder.

NOTE.—The fifth shot of the rival missed the target entirely.

Second Series.

Driggs-Schroeder.			Rival Gun.		
I. V.	1900	f. s.	I. V.	1821	f. s.
"	1862	"	"	1807	"
"	1852	"	"	1786	"
"	1862	"	"	1809	"
"	1865	"	"	1805	"
Mean	1868$\frac{1}{5}$	"	Mean	1805$\frac{3}{5}$	"

TARGET.



NOTE.—First shot of rival missed the target. Target distant 500 yards.

It will be seen that in both of these tests the Driggs-Schroeder was more accurate and gave higher velocities than its rival. The loading was the same in each case and the guns handled by the same crew. The Driggs-Schroeder gun is some 30 pounds lighter than its competitor, and besides has a greater strength of walls.

STRENGTH OF WALLS.

In all gun construction this is of prime importance, but it is doubly so in a gun to be handled in the manner of a rapid-firing arm, as, to make good practice, the crew must have confidence in the strength of the piece.

For this reason great care has been used in selecting the proper methods. The old style of forging the trunnions on the jacket was discarded, for the reason that a forging made in this way is not reliable, and, besides, that it forms entering angles that weaken the

construction. The forgings for the Driggs-Schroeder guns were therefore kept cylindrical throughout all the portion of the gun under the powder pressure. This avoids as far as possible abrupt angles and makes a uniform and homogeneous forging, as the whole length of each piece has the same amount of work put upon it in the forge, which is not the case in a forging that has to be forged cylindrical for a part of its length and then the trunnions drawn out at right angles to it.

The general construction of the gun is as follows:

The jacket, in two parts, the forward one of which is termed a sleeve, is shrunk upon the tube, the two parts being connected under the trunnion-band by the screw-thread of the latter. A jog in the adjacent surfaces of tube and sleeve transfers to the trunnions the thrust imparted by the rifling. The breech mechanism is contained in the rear of the jacket, which forms a natural housing and protection for the same.

The trunnion-band is not shrunk on the gun, but simply screwed on tight and pinned to prevent turning. In the guns built for the navy it has been omitted entirely, the gun screwing directly into the sleeve of the recoil mount.

The construction of all the guns is the same in principle. There is a slight change made in the 1-pounder, for the reason that it was intended to shift this gun about and to use it as a subcaliber piece for the large broadside guns. It was therefore thought best not to trust to the mounting to lock the tube and jacket, so for this purpose the sleeve was both screwed and shrunk on.

The general construction of the 6-pounder is shown in Plate A.

In favor of the guns themselves, independent of mechanism, attention is invited to their weight and length, high grade of steel, and the strength of the gun. Their length of bore is 45 calibers—longer, we believe, than any guns of their weight and strength in the world, and certainly longer than any guns of their weight in the United States.

The steel used is of the best quality, furnished by the Midvale Steel Co. and the Bethlehem Iron Co. The records of the Government Inspectors at these works show the steel used in the forgings to possess the following qualities:

Tensile strength, 90,000 to 135,000 pounds per square inch.
Elastic strength, 50,000 to 80,000 " " "
Elongation, 15 to 30 per cent of its length.
Contraction, 20 to 50 " " area.

PLATE. A.

6 Pounder.

The Driggs-Schroeder guns are shrunk together with shrinkages computed from the following formulæ, and each gun has the shrinkages computed for it according to the characteristics of the metal.

FORMULÆ.

$$P_1 = \frac{3\theta_1(R_2^2 - R_1^2)}{4R_2^2 + 2R_1^2},$$

$$\left.\begin{aligned} P_0^{(1)} &= \frac{3\theta_0(R_1^2 - R_0^2) + 6R_1^2 P_1}{4R_1^2 + 2R_0^2}, \\ P_0^{(2)} &= \frac{3\rho_0(R_1^2 - R_0^2) + 2R_1^2 P_1}{4R_1^2 - 2R_0^2}, \end{aligned}\right\} \text{Using the one that gives the less value.}$$

$$\varphi_1 = \frac{1}{E}\left[\frac{(4R_0^2 + 2R_1^2)P_1 - 6R_0^2 P_0}{3(R_1^2 - R_0^2)} + \theta_1\right],$$

$$S_1 = \varphi_1 \times D_1.$$

These formulæ are deduced from those found in Notes on the Construction of Ordnance No. 35, Captain Rogers Birnie, Jr., U. S. A.; the shrinkages being in terms of the pressures in a state of action, and on the hypothesis that the modulus of elasticity is constant and equal to 29,000,000 pounds. The elastic strength of compression is assumed to be equal to the elastic strength of tension.

To guard against the adoption of a shrinkage which would cause permanent compression of the bore, the variations of pressure in the states of rest and of action are computed by the formula:

$$p_1 = -\frac{R_0^2(R_2^2 - R_1^2)}{R_1^2(R_2^2 - R_0^2)} P_0,$$

and the resisting power of the tube by the formula

$$P_1^{(1)} = \frac{R_1^2 - R_0^2}{2R_1^2}\theta_0.$$

In all cases $P_1 + p_1$ has been found to be less than $P_1^{(1)}$.

R_0 = Interior radius of tube.
R_1 = Exterior radius of tube and interior radius of jacket.
R_2 = " " of jacket.
$\rho_0 = \theta_0$ = Elastic strength of metal of tube.
P_1 = Strength of tube alone.
P_0 = Strength of tube supported by jacket.
E = Modulus of elasticity = 29,000,000.
φ = Shrinkage per linear unit.

S_1 = Total shrinkage on diameter.
D_1 = Interior diameter of jacket.
θ_1 = Elastic strength of metal of jacket.

These formulæ, while not making so good a showing for strength of gun, are still the most reliable to work upon in constructing built-up guns.

The factor of safety is about 50 per cent, so that the actual elastic strength of the Driggs-Schroeder 6-pounder is about 30 tons per square inch. The ultimate or tensile strength of this caliber is about 40 or 45 tons per square inch, depending on the quality of the steel used.

The tube and jacket are proportioned, as near as possible, so that the exterior radius of tube will be a mean proportional between the interior of tube and exterior of jacket. This cannot always be done, but the nearer the approach to this proportion the stronger the construction. In all the Driggs-Schroeder guns this point is very nearly reached, and therefore the design is, theoretically, as near correct as it can be made.

BREECH-HOUSING.

The breech-housing being closed at the top excludes dirt and rain, while it is a great support to the rear end of the chamber.

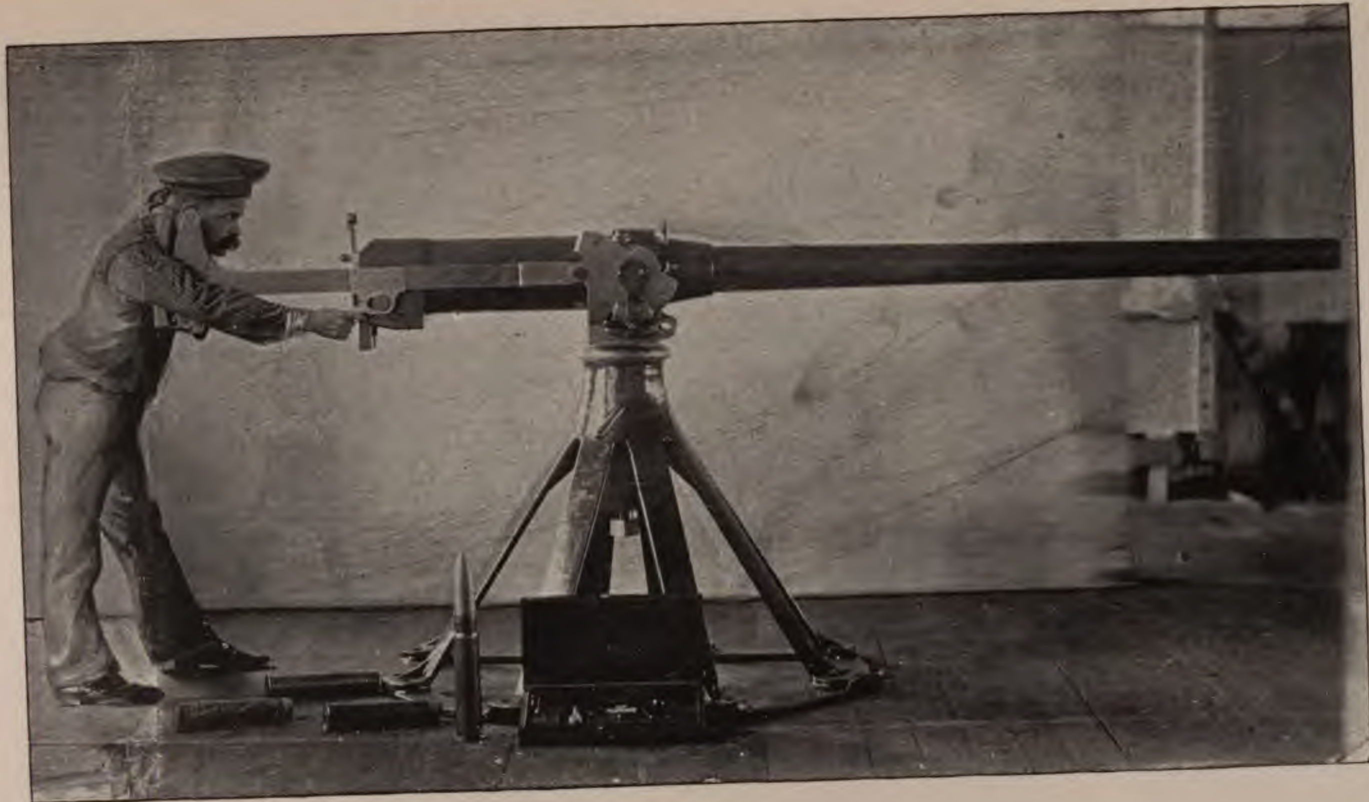
It has long been known that guns on the sliding-wedge principle were faulty in construction, because the breech-block, being held to the body of the gun simply by two side-pieces, the repeated strains brought these sides closer together and changed the shape of the chamber from round to oval.

GREATER RANGE, ACCURACY AND PENETRATION FOR THE SAME WEIGHT OF GUN.

The rapid-fire 3- and 6-pounders which were first put in service in this country had a length of bore of 40 calibers. Much of the weight of the gun was taken up in the weight of the breech mechanism and its housing.

When the Driggs-Schroeder was designed, a large amount of weight was saved at the breech, so that it would have been possible to make a 40-caliber gun on this design weighing some 50 pounds less than those in service at that time, but it was thought better to use the metal saved at the breech towards strengthening the chase and lengthening the bore. This was done, the bore being lengthened five calibers.

4-INCH GUN LATELY COMPLETED AT WASHINGTON YARD.



6-POUNDER.

This increase has put from 40 to 70 f. s. on the muzzle velocity of the shell, depending, of course, on the loading. On this point, the report made on the first 3-pounder tested at Annapolis, which was about 44 calibers length of bore, was as follows:

"Theoretically, the increase of velocity due to four calibers increase length of bore is about 70 f. s. The results of practice show that the theoretical conditions are fulfilled.

The following velocities were obtained:

Charge, 763 grams N. D.

Projectile, Hotchkiss common shell, 1500 grams.

I. V.	2042	f. s.
	2052	"
	2042	"
	2057	"
	2046	"
Mean	2048	"

PRESSURES.

The tests made on this point show that there is no difference between the pressures in this and in the Hotchkiss guns of the same caliber, the powder and projectile being the same."

The advantages therefore claimed for the Driggs-Schroeder guns (distinct from those claimed for the breech mechanism, mentioned later) are:

1. For same weight and strength of gun, greater range, accuracy and penetration.
2. A natural housing for breech mechanism.
3. More reliable construction.

2. BREECH MECHANISM.

The essentials of a good breech mechanism for any system of rapid-fire guns are:

1. Safety.
2. Ease and rapidity of working breech mechanism.
3. Certainty and force of extraction.
4. Protection of mechanism.
5. Complete ejection of the empty case.

SAFETY.

As regards this essential, the strength of the breech-block and its support, in the Driggs-Schroeder gun, is sufficient in the 3-pounder to sustain a chamber pressure of 60 tons per square inch, and in the 6-pounder 70, without in either case passing the elastic strength of the metal. The usual working pressure is only 15 tons per square inch. For further proof of the safety of the mechanism we quote from official reports on 3-pounder:

"The maximum pressure developed in the bore has been 18 tons. Under this and the frequent repetition of lower pressures (about 12 to 15 tons) the block has shown no signs of weakness.

If fully closed before firing, it is, I think, amply strong both in itself and in its support.

Experiments were made to determine whether the cap could be snapped and the gun fired before the breech was fully closed.

There was found to be no possibility of such an accident, the arm of the cocking cam being always interposed to prevent the firing pin from striking the cap until the breech is locked.

It is a feature of this system which gives it an advantage over certain others that the firing pin may be set and kept at half-cock. Tested in this position, it is found to be free from danger of accident.

It may be said, therefore, that the safety of the system is at all points satisfactory."

Report on 6-pounder is as follows:

SAFETY.

"The new locking device answers its purpose well. No liability of its being jarred or knocked open while firing was noticed. It was found there was no possibility of firing before the breech was closed and locked.

The strength and endurance of all parts appear to be sufficient."

EASE AND RAPIDITY OF WORKING BREECH MECHANISM.

The lightness combined with a revolving motion of the breech-block results in increase of rapidity of firing and decrease of fatigue in working. This is further augmented by the fact that the cartridge need not be accurately placed. If the case is within three-fourths of an inch of being home, the motion of the breech-block will complete

the loading as well as if the rim of the case was close against the extractors.

The breech-block of the 6-pounder Driggs-Schroeder gun weighs 26 lbs.; the corresponding part of the other 6-pounders in service weighs 59 lbs. The difference in the 1 and 3-pounders shows the same proportion of decrease.

This saving of weight is an important factor in rapid firing, especially if the maximum rate of fire is continued any length of time. Without doubt there is a great difference between the rate of fire of aimed and unaimed shots, and also the rate at which ammunition can be supplied will limit in a degree the rate of fire. This fact is brought forward by some ordnance men to sustain an assertion that there is no advantage in increase of rapidity of operating the breech mechanism. The supply of ammunition is not changed by changing the breech system; neither is the time occupied in pointing. The only operations, therefore, that vary with the change from one system to another is the loading and extracting. It is obvious, therefore, that the less time is occupied in these operations the less time there will be between the different shots, and this will be the case whether the gun is aimed or unaimed.

Ammunition is supplied in boxes containing from 11 to 40 rounds, so that the supply of ammunition would not change the rate of firing a volley, though it might change the time between the volleys.

It is plain, therefore, that the gun that can fire the greatest number of unaimed rounds can also fire the greatest number of aimed rounds, allowing the same time to each for pointing.

No test has ever been made in this country to determine the rate of aimed fire for any rapid-fire gun, so that no data on this point is at hand. The rate made with the Driggs-Schroeder 3-pounder, with an untrained crew, was 33 rounds per minute. This speed was attained on an official trial in England. The rate actually made in this country with the 6-pounder gun was 25 shots per minute, which was also accomplished with an untrained crew. This same crew (consisting of but 3 men) fired 61 rounds in 3 m. 36 sec. The official report on this part of the test is as follows:

"The rapid-fire test of 60 rounds, fired as rapidly as possible, was commenced at 11.05. The start was made with the breech open, and a cartridge in the hands of No. 3.

The times were made as follows:

1st	10 rounds in			27 seconds.		
2d	10	"	"	30	"	
3d	10	"	"	35½	"	
4th	10	"	"	44½	"	including 1 misfire.
5th	10	"	"	34½	"	
6th	10	"	"	44½	"	

Total, 3 m. 36s.

The last round was fired at 11.08.36.

The test virtually occupied the time of 61 rounds, or on an average of 3.54 seconds to a round. When the misfire occurred, the time from fire to fire was 12 seconds.

At the end of this test the face of the breech-block was cool to the hand. The temperature of cylinder over chamber 92°. At the muzzle the temperature rose to 175° in 1 min., and continuing to rise, reached the limit of the thermometer, 212° in 1½ min., the mercury boiling and solder melting."

For a practiced crew the reports are as follows:

"With a well-exercised crew the gun could, I think, be fired at the rate of 30 rounds a minute, for one minute or less."

CERTAINTY AND FORCE OF EXTRACTION.

In the Driggs-Schroeder there are two independent extractors, either of which will extract the case. Besides this advantage, two extractors are better than one, for the reason that, being placed so as to press on the rim at opposite ends of a diameter, the case is not cramped by being pressed over to one side; also, if the rim is a little weak it is more likely to hold, as the strain is divided between the two points of contact with the extractors.

Since the trial of the first experimental Driggs-Schroeder 3-pounder at Annapolis in February, 1888, there has not been a failure of a single extractor, though the guns have fired over 1000 rounds.

All of the Driggs-Schroeder guns, both large and small, are designed to eject the empty case well clear of the gun after firing, and this seems to us indispensable for a rapid-fire gun. Where the empty case has to be handled and withdrawn from the gun by hand, time is lost, and unless great care is taken, the man whose duty it is to handle the empty case is liable to burn his hands, as they often come out very hot. During one of the trials of a 6-pounder the empty cases collected about the rear of the gun, and one coming in contact with

the shoe of the captain of the piece, burnt the leather. With this experience it seems advisable to handle empty cases fresh from the gun as little as possible. If large-caliber guns cannot be designed to entirely eject the case and it is necessary to handle them, heavy gloves covered with some non-conducting substance might be used to protect the hands, but when there are large rapid-fire guns that work well it seems unnecessary to go to the trouble of getting special gloves and losing time to handle hot empty cases.

PROTECTION OF THE MECHANISM.

The housing for the breech mechanism is only open at the bottom and rear, so that the mechanism is entirely protected from shot or falling fragments; the only pieces exposed are the pistol-handle on one side and the operating-handle on the other. Even were the pistol-handle shot away the gun could still be worked, and almost as efficiently as with it. In designs having the housing for the mechanism open at the top, falling fragments are apt to lodge there, rain beats in, and on shore sand and dust will collect in the mechanism. Besides this, a breech-block supported only at the back requires much more metal in the housing than should be put in this part of the gun.

In almost every system using a sliding or vertically moving block this part of the mechanism projects beyond the housing both at top and bottom, so that even when the gun is closed the breech-block, which is the keynote of the whole mechanism, is at all times exposed to accidental blows or injury in action.

The use of the screw-plug for rapid-fire guns is even worse.

In all the systems devised to utilize this mode of closure, almost the entire mechanism is exterior to the gun. To perform the many motions necessary for the plug to go through requires a complicated system of cogs and levers. The plug must be revolved, withdrawn and swung around on a tray; all with one motion of the handle. On the tray the plug is only held in place by the friction due to its own weight on a movable knuckle. The whole mechanism must be entered and withdrawn at every fire. A slight displacing of the breech-block in the tray (which is an easy matter) will prevent the plug being returned to the gun.

During all the operations of loading the whole mechanism is out of the gun and at the side, exposed to accidents of all kinds.

Peculiar as it is, it is still a fact that many officers think that any

system using the interrupted screw-plug is good because it utilizes that closure, and yet this same interrupted screw-plug has a longer record of accidents, injuries and deaths than all the others put together. Very few professional men who read this paper but who can recall some serious accident from the use of the screw-plug breech-closure. They invariably have an explanation of the cause, but that is little satisfaction to the victim or to his friends.

The advantages, therefore, of the Driggs-Schroeder system over others may be condensed as follows:

1. No danger can result from a hang-fire or misfire.

2. The gun can be left loaded and half-cocked and can be cocked again without opening breech.

3. The mechanism is thoroughly protected from small shot and accidental blows.

4. The breech-block is 50 per cent lighter than some other systems, and lighter than any known, from which results:

5. Greater length of gun for same weight. This results in:

6. Greater velocity and therefore greater muzzle energy.

7. (4) also results in a greater rapidity of fire over other systems of from 5 to 10 shots per minute.

8. Since the block revolves, the full weight of the block is only felt for an instant.

In long-continued firing this would be of the greatest importance to the operator.

9. From (4) it is evident that the system can be carried to heavy guns.

The block of the Driggs-Schroeder 36-pounder only weighs 68 pounds, the full weight of which is only felt for a drop of one inch.

10. The shoulder-piece is on the right side, which is the natural position to fire.

11. Three men only are required for a crew.

12. The handle being on the left side, the loading and operating is done on the left side of the gun. This leaves the captain of the gun (who is on the right side with his right shoulder against the shoulder-piece, and the right forefinger on trigger) with a clear field of vision, so that pointing and loading go on together.

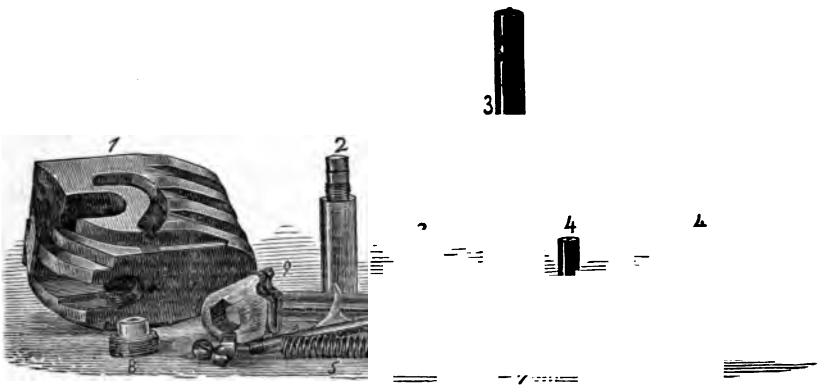
13. The cases need only be pushed to within one inch of extractors.

Regarding the handling and pointing of the piece we quote from the official report upon the Driggs-Schroeder guns, tested at Annapolis, as follows:

" The shoulder-piece of the gun is on the right-hand side and the handle on the left. There result from this arrangement, taken with the lightness of the block, certain marked advantages.

The man who works the handle is on the left of the gun. He can work the handle perfectly with the left hand, which leaves his right hand free for loading and inserting the cartridges.

We found in actual firing not only that this arrangement, which does away with one man and reduces the crew of the gun to three, is practical, but that it is much better than to have four men. As the same man inserts the cartridge and closes the breech, there can be no danger of jamming the cartridge or the hand by starting up the block too soon."



1. Breech-Block.—2. Guide Bolts.—3. Main Bolt.—4. Extractors.—5. Firing-Pin and Spring.—
6. Operating-Handle.—7. Sear-Bolt Spring and Cap for Holding Spring in Place.—
8. Screws for Holding Face-Plate in Place.—9. Operating-Cam.

DESCRIPTION OF THE BREECH MECHANISM.

Referring to the drawings, Fig. 1 represents a longitudinal section of the breech end of the gun and the breech-block, the cam and firing-pin being shown in side elevation, and other parts and features in dotted lines. Fig. 2 shows the same with the breech-block moved back into position for opening the chamber for the introduction of a cartridge. Fig. 3 is a rear elevation of the breech of the gun, with the breech-block closing the chamber, and a number of other parts and features shown in full and dotted lines. Fig. 4 shows a detail side view of the breech-block. Fig. 5 shows a front view of the same. Fig. 6 is a rear view of the cam in detail. Figs. 7 and 8 are respectively side and rear views in detail of the extractor-arm for the

right side of the breech-block. Fig. 9 is a detail side or edge vie of the sliding leaf for holding and releasing the firing-pin. Figs. 1 and 11 are broken horizontal sections of the breech-block and slidir leaf, said sections being respectively taken on the dotted lines x and $y\ y$, Fig. 3. Fig. 12 is a vertical section of a part of the breecl block on the dotted line $z\ z$ of Fig. 1, showing the form of the cavit at that point. Fig. 13 is a broken side view of the breech and tl operating handle, showing the spring-catch in the latter and tl recess therefor in the former.

In the drawings, A represents the breech-block, which is provide on its upper surface with bands $a\ a$, which fit into correspondingl shaped grooves or recesses $a'\ a'$ in the upper interior surface of tl breech A', and extend downward a suitable distance within the wal of the breech A^2. These bands and their grooves firmly hold tl breech-block in position and prevent backward movement of the sam during firing.

The breech-block A is formed with a cavity, A^3, extending fro the front toward the rear, the general contour being represented i longitudinal and transverse section in Figs. 1 and 12. Formed i the front part of the cavity is a curved wall, 1 2, of suitable lengtl which merges into an upwardly inclined wall, 2 3, and in the re upper part of the rectangular portion of said cavity is a round pin, immovably secured therein.

The central front face of the breech-block containing the cavity covered by a strong face-plate, 5, which is held in place by a lockin plug, 6, screwed into the same and the cheeks of the cavity.

In the sides of the breech-block are formed cams or guide-groov 7 7, which are of the shape shown in dotted lines in Fig. 1 and full lin in Fig. 4, their lower or rear walls from 8 to 9 being nearly vertical, b slightly inclined forwardly. From the point 9 said guide-grooves co tinue on in curved lines from point 10 to point 11, the two latter poin of said grooves being concentric with the axial bolt when in the upp part of the elongated opening in the breech-block, the purposes an functions of these parts and features being hereinafter fully describe Projecting into the guide-grooves 7 7 are guide-studs 12 12, whic are secured in the walls of the breech. The elongated opening 13 also formed in the breech-block—in its lower portion—and is incline forward two or three degrees from the vertical, so as to allow of movement of said block when closing. A strong axial bolt B passe through said elongated opening, fits in openings in the walls c

PLATE I.

Fig 1.

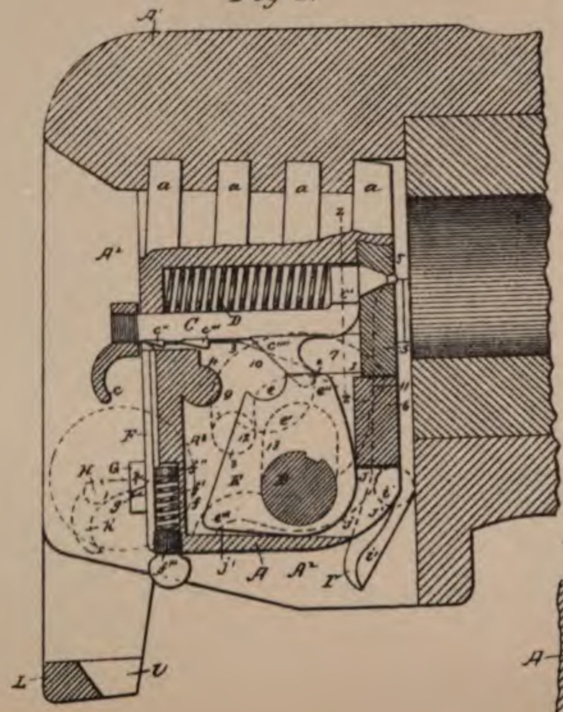


Fig. 12.

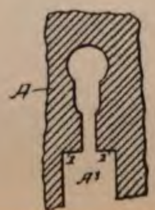


Fig. 2

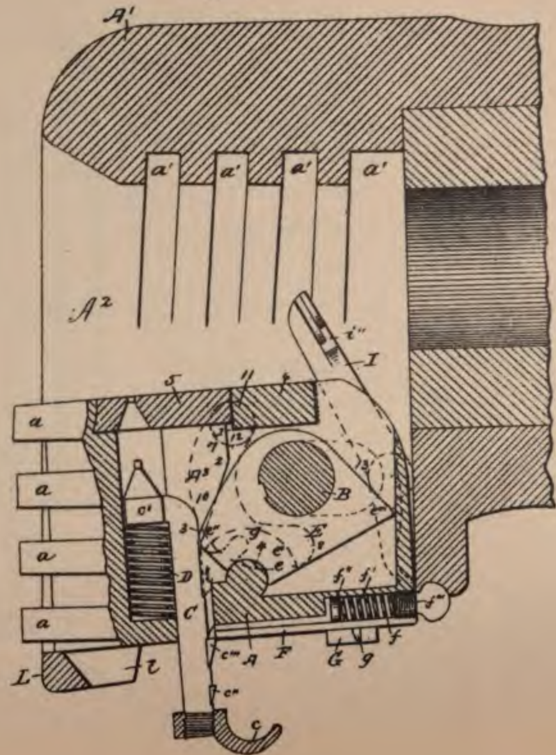


PLATE II.

Fig. 3.

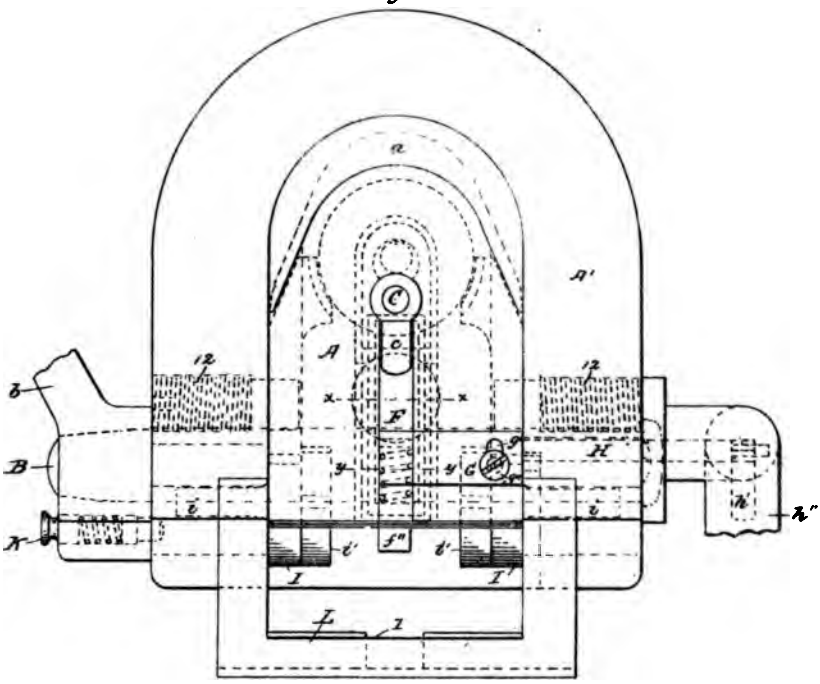


Fig. 4.

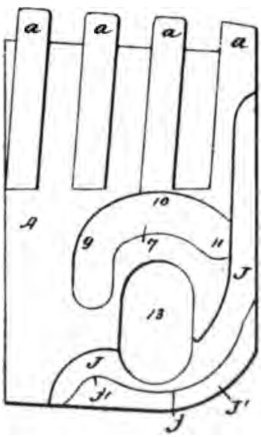


PLATE III.

Fig. 5.

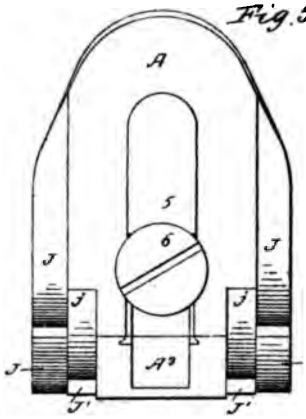


Fig. 6.

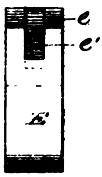


Fig. 9.

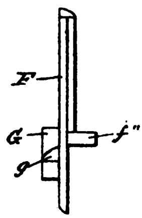


Fig. 7.

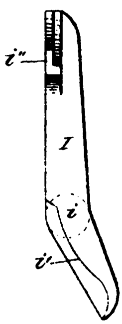


Fig. 13.

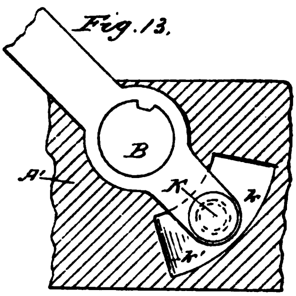


Fig. 8.

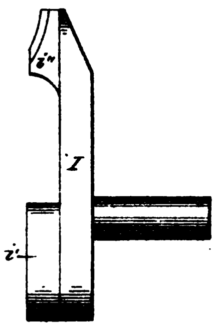


Fig. 10.

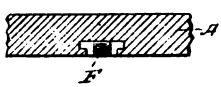
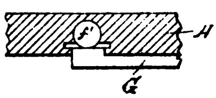


Fig. 11.



cheeks of the breech, and extends out beyond the same on the left side, where it is provided with an operating handle, *b*.

In the upper part of the cavity in the breech-block, or above the rectangularly shaped part of said cavity, is arranged the firing-pin *C*, which is provided at its rear end with a finger-loop *c*, and at its front end with an upturned head, c'. On the under side of this firing-pin, toward its rear end, are respectively formed half and full cock-studs, c'' and c''', and a downwardly and forwardly extending cocking-lug c'''' is arranged near its middle. In the top portion of the cavity, above the firing-pin, is arranged a spiral spring, *D*.

In the left upper end of the cam *E*, and extending its full width, is formed a circular recess, *e*, which is struck with the same radius as the rounded pin 4 in the cavity of the block. Beneath said recess *e* and in the middle of the upper rear part of the cam, is formed a larger curved and walled recess e', as shown in dotted lines in Fig. 1 and in rear view in Fig. 6, which terminates in front at the point e'' of the cam. This point, when the breech-block is closed, rests beneath the curved wall 1 2 of the cavity and supports said block in raised position. At the rear lower end of the cam is a toe, e''', which, when said cam is turned backward, exerts a downward pressure upon the lower wall of the cavity in the breech-block and cams the block down.

In the rear of the breech-block is located the sliding leaf *F*, which holds and releases the firing-pin, and which fits in a mortise cut in the rear face of the block and extends downward from the hole for the firing-pin. Side views of this sliding leaf are shown in Figs. 1 and 9, and transverse sections of the same and its mortise in Figs. 10 and 11, which are respectively views on the dotted lines *x x* and *y y* of Fig. 3. A coiled spring *f* is located in a vertical cylindrical recess, f', in the rear wall of the breech-block and presses the sliding leaf up against the firing-pin. The top of this spring bears against a flat circular lug f'' on the front side of the leaf. The spring is introduced at the bottom of said recess and held in place by a plug f'''. From the rear face of the leaf projects a laterally extending arm, *G*, which terminates in a lip *g* having a rounded rear face as shown in Figs. 1 and 9. A vertical slot g' is formed in said arm, and a screw-stud g'' passes through the same and into the block, whereby the vertically sliding leaf is kept in proper alignment.

A small rock-shaft, *H*, passes transversely through the right wall of the gun-breech, and its inner end terminates in a recess in said

wall in rear of but out of line with the side of the breech-block. On the inner end of said rock-shaft is a trip or finger, *h*, which is normally just in contact with the rounded lip *g* of the laterally-extending arm *G* of the sliding leaf *F*, while on the outer end of said rock-shaft is secured a finger-piece or trigger, *h'*, which projects downward beneath the usual hand-rest or pistol-grip, *h''*, and which, on being pressed by the finger, causes the trip *h* to bear down upon the lip *g* of arm *G*, and thus slide the leaf *F* downwardly against the resistance of the coiled spring *f* and liberate the firing-pin *C*, which then flies forward against the primer and explodes the cartridge.

The cartridge-case extractor consists of two upwardly-extending arms, *I I*, provided with lateral pins or pivots *i i*, which project into openings in the inner surfaces of the walls of the breech. As the breech-block *A* is flush with or takes up the whole width of the breech-chamber, the sides of said block, along its bottom and front surfaces, have formed therein recesses *J J*, which are of a depth inward from the sides of said block, equal to the width of the long or main portions of the extractor-arms *I I*, sufficient room being provided at the upper ends of said recesses to permit the block to descend slightly along the extractor-arms previous to the commencement of its rotary movement. On the inner sides of the extractor-arms, along their lower rearwardly-projecting ends, are formed curved projections *i' i''*, which extend into recesses or steps *J' J'*, formed along the lower front and bottom parts of the breech-block, and which are still deeper or cut farther in from the sides of said block than the recesses *J J*. These deeper recesses or steps, when the breech-block descends to its revolving position, will bring their upper curved walls, *j j*, in contact with the curved projections *i' i'* on the inner sides of the extractor-arms. These upper walls, *j j*, of the deeper recesses or steps *J' J'* are circular in form for a certain distance, as shown in Fig. 4, and are slightly eccentric with respect to the center of rotation of the block, so that during its rotation, as hereinafter described, said walls will press slightly and slowly against the curved projections *i' i'* on the inner sides of the lower ends of the extractor-arms, and thus cause the heads *i'' i''* of said arms (said heads being suitably fashioned to grasp the rim of cartridge-case) to move slowly to the rear and pull the shell along with them. At the rear ends, *j' j'*, of the deeper recesses or steps *J' J'* the upper walls, *j j*, change in curve abruptly downward; hence these abrupt curves, coming in contact with the curved projections on the extractor-

arms, when the block has rotated sufficiently to the rear to fully expose the bore of the gun, will cause the extractor-heads i'' i'' to suddenly pull or jerk the cartridge-case and throw the same quickly to the rear.

Secured within the interior surfaces of the breech-walls, and suspended therefrom at the extreme rear of the breech, is a strong tray or support, *L*, which receives and sustains the weight of the breech-block when it is turned back and the bore is open for loading. As the cam *E* rotates rearward and the block *A* descends, the cocking-lug c'''' of the firing-pin *C* takes against the bottom of the curved walled recess e', formed in the middle of the upper rear part of said cam, and is moved rearward, the portion of the cam in front of said recess passing up into the curved front part of said cocking-lug. This pushing or retracting movement imparted to the firing-pin is effected against the resistance of the spiral spring *D*, which is contracted thereby, and said movement is continued until the circular recess *e* in the cam embraces the round shoulder 4 in the cavity, when the relative motions of the cam and firing-pin cease. When the recess *e* of the cam comes in contact with the round shoulder 4, the full-cock stud c''' of the firing-pin has passed the rear of the block and is caught by the sliding leaf *F*, before described.

Fig. 1 represents the breech of the gun as closed, or as it would appear after a discharge. To open the bore, the handle *b* is pulled to the rear, which turns the axial bolt *B* and the cam *E*. When the latter has been turned back a sufficient distance to cause its front point e'' to pass out from beneath the wall 1 2 of the cavity in the breech-block, the toe e''' of said cam will press down upon the bottom wall of the cavity and force said block downward, this movement being permitted by the point e'' of the cam moving along the inclined wall 2 3 of the cavity. After further turning the cam, accompanied by the downward movement of the block, its circular recess *e* embraces the rounded pin 4 in the cavity, and after this the further rotation of the cam is necessarily accompanied by the rotation of the block, which by this time has descended far enough for its axial bolt *B* to move to the upper part of the elongated opening 13, and for the bands to clear their grooves in the breech. After this, the movement of the block is rotary and to the rear around the axial bolt, it being guided by the cam-grooves 7 7 in its sides, and the guide-pins 12 12. To close the gun, the handle *b* is turned forwards. At first the rounded shoulder 4 remains engaged in the circular

recess *e* of the cam and causes the block to swing upward. In the meantime the guide-grooves in the sides of the block move over the pins or studs. On reaching point 10, in consequence of the change of the curves of the grooves, the upper surfaces or walls of said grooves take against the pins and are moved upward, thus forcing upward the breech-block and disengaging the rounded pin from the circular recess *e* of the cam. When this is effected, the front point *e''* of the cam commences to impinge at the point 3 in the cavity, and the rotary motion of the cam continuing, moves along beneath the inclined wall 2 3 in said cavity and forces the breech-block upward. In the meantime the guide-pins change position in the grooves, moving from points 9 to points 8; also, the axial bolt changes position from the top to the bottom of the elongated opening 13. When the point *e''* of the cam reaches the lower or front end of the inclined wall 2 3, it moves a short distance beyond the same and beneath the wall 1 2 in the cavity and firmly supports the breech-block in its raised and closed position. Further forward motion of the cam is prevented by coming against the face-plate 5, and by th catch on the handle.

TABLE OF GENERAL DIMENSIONS AND WEIGHTS OF DRIGGS-SCHROEDER GUNS.

	1-pdr.	3-pdr.	6-pdr.
Caliber, inches	1.457	1.85	2.244
Length of bore, inches	58.28	81.45	100.98
Length of bore, caliber	40	44	45
Length of rifling, inches	51.9	65.75	98.3
Length of gun, "	61.08	87.26	107.98
Number of grooves	12	20	24
Depth of grooves, inches	0.015	0.0158	0.015
Width of lands, "	0.0594	0.0787	0.0737
Weight of gun complete, lbs.	100	497	800
Weight of breech-block, "	5	16	26
Weight of powder, ounces	4.6	27.53	31.5
Weight of projectile, pounds	1.1	3.3	6
Muzzle velocity of projectile, f.s.	1800	2100	1880
Number of fires per minute	40	33	30

Twist of rifling, 1-pounder—1 turn in 30 calibers.
" " 3-pounder—1 turn in 100 to 1 in 25 calibers.
" " 6-pounder—1 turn in 150 to 1 in 27 calibers.

In the 3- and 6-pounder the twist of rifling is that of a semi-cubical parabola. Theoretically, this curve produces less strain on the rotating band than any other, and less than a uniform curve.

SIGHTS.

The sighting of the guns is such as to admit of either quick rough sighting or very close fine sighting.

The sights, both front and rear, have rings one inch interior diameter each, through which the line of sight passes.

In the front ring there are single cross-wires, and in the rear sight-ring double cross-wires. For rough sighting it is sufficiently near to keep the rings concentric and the target in the center without regard to the wires. At the distance the front sight is from the rear one the front ring appears considerably smaller than the other (about one-quarter inch diameter) so that the eye will catch the position of center with a very small error. The advantage of the rings is that they give a clear view all around the target, and the motion of the platform and of the target can be anticipated and the sights kept on with little difficulty. With the sight-notch in a solid bar the target is only visible when it is above the line of sights, and motion of the ship or target cannot be anticipated.

When no other drill is provided the following is used:

DRILL OF THE 1-POUNDER, 3-POUNDER, AND 6-POUNDER DRIGGS-SCHROEDER GUNS. (CREW OF 3 MEN.)

Nos.	Stations.	Arms, Revolvers.
1	1st Captain	1
2	2d Captain	1
3	Shellman	1

(*Note.*—The crews of the secondary battery are not assigned as boarders or riflemen.)

The exercise supposes the guns to be mounted in place and lashed, as well as clamped against elevation and train.

WORDS OF COMMAND.

I. Silence! Cast loose and provide!
II. Load!
III. Point!
IV. Commence firing!
V. Cease firing!

VI. Unload.

VII. Secure.

A gun's crew consists of three men, all of whom should be, as far as practicable, thoroughly trained rifle-shots.

The stations of the crew for mustering, when the gun is secured, are as follows: For guns mounted on deck—in line, directly in rear of the gun, facing inboard, No. 1 on the right; for guns mounted aloft—on deck, abreast the mast, facing outboard, No. 1 on the right.

I.—*Silence.*

This is preparatory, and is given to secure attention to the following order:

CAST LOOSE AND PROVIDE.

1 commands; removes gun cover; casts adrift gun lashings; places sight cover clear; ships gun stock; tests breech mechanism; examines bore; sees in place gear and implements for the service of the gun; for drill, puts on drill washers.* When all is ready, reports to officer in charge and takes station in rear of and facing gun.

If gun is mounted aloft, he first goes aloft and sends down tackle for hoisting up ammunition and other articles for the service of the gun; receives articles whipped up by 2 and 3.

2 provides and examines the reserve box containing the accessories and spare parts;† provides three revolvers and belts, and puts revolvers in rack near the gun; provides clean swab; adjusts drill apron;‡ sees trunnion and pivot clamps in working order; sees carriage in working order; takes his station at left side of breech and facing it. If the gun is mounted aloft, he does not go aloft until all the articles for the service of the gun have been whipped up; then secures net to top under lubber's hole.

3 provides swab and bucket of water; brings ammunition from hatchway§ and places it in rear of gun amidships; takes station alongside the ammunition. If gun is mounted aloft, assists 2.

After performing his duties, every one will put on his belt with revolver. After inspection by the division officer, and at his order "*Lay aside belts and arms,*" the belts and revolver will be removed and placed clear of the gun.

II.—*Load.*

1 places right shoulder to stock; seizes the directing handle with left hand, and as soon as gun is unclamped, lays it with muzzle outboard; plants feet firmly to resist motion of the ship.

* See note 12. † See note 14. ‡ See note 13. § See note 2.

2 assists 1; unclamps pivot and trunnion clamps as soon as 1 has his shoulder to the stock; grasps with left hand and throws back smartly breech-block lever, opening breech;* takes cartridge from 3, points the shell fairly, and then enters it smartly in the gun and closes breech.† Performs duties of 3 while the latter is providing fresh box of ammunition.

3 passes cartridges to 2.

III.—*Point.*

1 steadies the gun with the right arm and shoulder; adjusts sight, seizes pistol-grip, finger on trigger, and with his eye ranging over the sights, steadies the piece upon the object.

2 attends trunnion and pivot clamps. At a sliding pivot mount, adjust the position of pivot for train.

IV.—*Commence Firing.*

1 tends sight, rectifies aim and fires;‡ after reloading again rectifies aim and fires, and so on.

2 tends clamps and loads.§

3 supplies ammunition to 2, and in rapid firing stands by to relieve him; keeps empty cases clear of gun; when ammunition is nearly exhausted, provides a fresh supply.||

V.—*Cease Firing.*

1 removes his hand from pistol-grip, and steadies the gun until the pivot and trunnion clamps are tightened.

2 tightens trunnion and pivot clamps; half-cocks.

VI.—*Unload.*

2 grasps breech-block lever and draws it back *easily* with left hand, keeping right hand in rear of breech opening; removes cartridge;¶ passes it to 3; sponges bore if necessary; closes breech.

1 eases firing-pin forward when breech is closed, then, assisted by 2, cleans and oils mechanism, if necessary.

3 receives cartridge from 2, replaces it in box,** then closes box.

* See notes 4, 6 and 7. † See notes 3 and 5. ‡ See notes 8 and 9.
§ See notes 3, 4, 5, 6, 7 and 8. || See note 2. ¶ See note 6.
** See note 10.

VII.—*Secure.*

The numbers return what they provided, and secure what they cast loose, the gun having first been laid to the securing position.*

DIRECTIONS FOR DISMOUNTING AND ASSEMBLING THE MECHANISM.

1-pounder, 3-pounder, 6-pounder Driggs-Schroeder on non-recoil stand.

No. 2 clamps the gun.

3 backs out right guide-bolt; 1 raises rear end of stock; 3 re-enters guide-bolt (not far enough to engage in guide-groove); 1 lets stock down to rest on it. (If it is desired to take stock off entirely, 3 removes its pivot-bolt on the Y and takes it off.)

The breech being closed, 2 backs out left guide-bolt; takes off operating handle; taps end of axial-bolt to start it; 1 holds block from underneath with left hand, and with right hand holds on to finger-catch of firing-pin; 3 draws out main bolt, assists 1 to lower block out of place.† The block being out, 1 full-cocks; 3 removes face-plate; 1 uncocks by bearing down on sear arm, and then takes off finger-catch on rear end firing-pin;‡ 3 takes out firing-pin and spring; 1 takes out sear-plug, sear-spring and sear; 2 takes off sight, takes out extractors, removes pistol-grip, trigger, rock-shaft and tray.

Except in rare instances, such as dismounting for transportation or cleaning the sights, pistol-handle and tray should not be removed.

To Mount.

Proceed in the reverse way to dismounting; firing-pin must be full-cocked before putting in face-plate, and let down to half-cock after face-plate is in place.

DETAIL NOTES UPON THE EXERCISE OF DRIGGS-SCHROEDER GUNS.

1. To secure to the crew the freedom of movement necessary to the efficient serving of the gun, arms and equipment should not be carried until required for use.

2. The number of rounds of ammunition to be brought to each gun as a first supply will be regulated by the commanding officer, and will depend upon the requirements at the time. In the absence of orders, a full box will be supplied.

* See note 11. † See note 16. ‡ See note 15.

During action the ammunition supply for R. F. guns is dependent mostly upon the rapidity with which it can be whipped up from below. It would be impossible to supply it as fast as it could be used in continuous rapid-firing. It will therefore be necessary to take advantage of all interruptions of fire to increase the supply at the gun, with a given whipping capacity; the carrying from the hatches to the guns depends upon the distance and accessibility. One man, named conveniently Supply-man, assisted by No. 3 of each gun, can probably supply ammunition to four guns (two on a side) as fast as it is received from below. There may, therefore, be a Supply-man detailed for every four guns of the secondary battery. With Driggs-Schroeder guns, Nos. 1 and 2 can fire 12 to 15 shots a minute with No. 3 away.

3. In inserting the cartridge, 2 will keep it in mind to hold the rear end slightly raised with reference to the point, so as to avoid driving the point of the shell against the upper edge of the chamber. The lower edge and sides are protected respectively by the breech-block and the extractors.

Neglect to observe the above precaution may result in a burr about the upper edge of the chamber.

While it is not necessary that the case should be pushed home against the extractors, it will be safer to send it well home. The extractors have a certain amount of yielding that will accommodate itself to any severity of ramming within reasonable limits.

4. If, after firing, the cartridge-case sticks after partial extraction, fully extract and then look for dirt or caked powder in the chamber. If such exists it must be removed with sponge if there is time.

5. If, in loading, a cartridge jam and will not let the breech-block close, never attempt to drive it home by forcing the block; unload at once, put the cartridge aside and try another.

6. If the case does not extract, ram it out from the muzzle.

7. If one extractor breaks, the other will extract satisfactorily; but the first opportunity should be taken to put in a new one: back out the guide-bolts, half-cock, draw axial-bolt, holding the block by hand; lower the block far enough to expose the extractor, resting the upper part on the tray for support; pull out the broken extractor and put in the new one. Do not put in the new extractor with a cartridge already in the gun, as the rib will come on the wrong side of the cartridge-head.

8. If the primer misses fire, full-cock again without removing block; in so doing the tension of the main-spring will indicate

whether or not it is broken. If it feels stiff enough, but misses again, open and extract, put in new cartridge and try again. If it still misses, dismount the block, remove the face-plate and renew the firing-pin or spring, whichever is found defective. If the cap should have failed to obturate at any shot it is possible that a residuum may have been deposited on the front end of the firing-pin or rear face of face-plate, which might shorten the throw of the former and prevent it striking the cap.

9. In action do not try a second time any cartridge that has once failed unless it is absolutely necessary. To do so is an unnecessary experiment by which a telling shot may be missed.

10. In returning ammunition great care must be taken that empty cartridge-cases are not put in ammunition boxes containing loaded cartridges, and *vice versa*. 3 is held responsible for attention to this.

11. After ammunition boxes have been sent below, and before stowing them in the fixed ammunition rooms, the men stationed in the latter will redistribute the ammunition so as to completely fill all partially filled boxes but one. This last partially filled box should never be sent on deck in supplying.

12. The drill-washers are designed to prevent the firing-pin from delivering a sharp blow on the face-plate when snapping the gun at drill, and from delivering too strong a blow when drill cartridges are used. They should not be kept on when the piece is secured, as they increase slightly the compression of the spring when uncocked.

13. The drill apron is used only when the exercise is with drill cartridges.

14. Reserve boxes for 6-pounder, 3-pounder and 1-pounder contain the following accessories and spare parts:

Accessories—Sponge brushes, cleaning brush, oil can, screw-driver (special), clamping wrench, drill-washers.

Spare parts—Firing-pin, firing-springs, right and left extractors, sear, sear-springs, set of gun-screws.

15. In dismounting, the firing-pin must be uncocked before taking off the finger-catch, otherwise the former would fly out with some force and possibly be lost.

16. In lowering the block, tip the upper end slightly to the rear as soon as the bands are disengaged, and, holding on to finger-catch, lower block (forward of tray) in the hands of No. 3.

17. Lard oil should not be used on any part of the mechanism, as it hardens in cold weather. Mineral or fish oil is best.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

REMARKS ON THE ORGANIZATION OF NAVAL ENGINEER FORCES.

By GEORGE QUICK, Fleet Engineer, Royal Navy, Retired.
(Member U. S. Naval Institute.)

I venture to submit the following remarks to the members of this Institute, because, when I first made some little acquaintance with the United States Navy, some thirty years ago, I considered it was, as regards its engineer officers, the best organized navy in the world. And now it appears to me that the paper by Lieutenant Fullam, U. S. N., on "The System of Training and Discipline required to Promote Efficiency, etc.," and the Prize Essay by Ensign Niblack, U. S. N., on "The Enlistment, Training and Organization of Crews for our New Ships," and the discussions thereon, published in these Proceedings, Nos. 55, 57 and 58, plainly show that the United States Navy contains officers who are quite as progressive and broad-minded as any men in the world; and that, therefore, the remarks in this paper will be freely and fairly discussed on their merits, and that all weak points will be fully and fairly shown up.

In these days of rapid development of machinery, we are all of us tempted to wish that a vast leap forward could be made at once, so that we may have our power produced without the use of coal and steam on board ship. For more than thirty years the hope has been indulged that the use of liquid fuel would enable us to avoid the horrors of coaling ship; but even to-day we seem to be far off from this step forward being taken. Those who have had to superintend the coaling of a man-of-war in a tropical climate, when the steam has been up and the coal has been old and dusty, can alone realize what an immense blessing liquid fuel would be to all on board if it could only be brought into constant use. But there are certain objections to its employment

on board vessels of war, which objections do not apply to its use on merchant steamers or fast mail boats, so that we must expect to see it employed successfully in the mercantile marine before it is used in vessels designed for fighting. It is true that those enterprising people, the Italians, are making strong efforts to introduce it into their war ships; but it is possible that an action at sea, in which high-explosive shells may be used, may very much alter their views on this subject.

But far better than liquid fuel would be the use of stored-up electricity for the propulsion and production of power for the use of war-ships. Could we bottle up in a volume of one cubic foot, and in a weight not exceeding 100 pounds, and at a cost not exceeding one dollar, sufficient electricity to develop one horse-power continuously for 1000 hours, we should have arrived at a state of almost ideal perfection as regards power for propulsion and power for working the various machines on board ships of war. Then we could dispense with coal bunkers, boilers, funnels, heat, smoke, dust, dirt and stench, and nearly all the other abominations connected with steam.

Personally, I should rejoice in such an improved state of things on board ships, for I have no love for things as they are. I have no reverence for things simply because they are old, although I have a very great dislike to any change that does not bring an improvement commensurate with the trouble and expense of effecting the change. But I am certainly not prejudiced in favor of coal and steam, although I have been connected with them all my life.

Now, although I do not venture to say that within the next thirty years some new inventions in chemistry and electricity may not render electric propulsion possible and profitable, yet, unfortunately, I cannot see any hope of its introduction in the immediate future.

At this moment we have as little to do with the distant future of thirty years hence as we have to do with the remote past of three hundred years ago. It is almost as great a folly to look too far ahead as it is to be always looking back upon the past. In some armies and in some navies it is the fashion to allow the past to dominate the present. With that fashion I am not in accord. It is simply childish to be governed by the iron rules of past practice. On the other hand it is presumptuous conceit and vanity to disregard the lessons of past experience.

Let us for one moment consider a large example of the result of slavish obedience to the rules of the past. Let us turn our eyes to the year 1866, and to the Austrian army under Marshal Benedict, enslaved by the rules and traditions of the past, and we shall see the frightful

fruit arising from the worship of the dead past—we see the field of Sadowa, the crushing of a mighty army and the humbling of the proud Austrian empire.

Let us look again to 1866. We see the Prussian army governed by the thoughts and reason of living men. Those men had learnt a living lesson from the experience of the past. They had learnt that things must progress—that there is no standing still. They had altered their arms, their drill and their tactics, under the guidance of the progressive Von Moltke, who would not be bound by the practice of his youth or by the traditions of his predecessors. And we look again upon the field of Sadowa, and we see the glorious success of the Prussian army which had learnt from the experience of the past, from the wars in Europe and from the great civil war in America. It had learnt to cast aside the leading-strings of its childhood and to think and to act as reason and circumstances required, and thus it crushed and conquered the army which was governed only by the rules and practice of a dead generation.

It is useless to multiply instances to show the value of progress in war matters. Those who are opposed to progress should prove their case by showing how and when nations have suffered by adopting improvements in arms, improvements in organization and improvements in tactics.

I venture on the foregoing remarks because it has been my fate to meet with so many people who object to all change and who express their preference "for the good old times" when there was neither steam nor engineers on board of men-of-war. But amongst American officers there is probably less of this desire for retrogression than amongst any other naval officers in the world. Nevertheless, the views I have held for many years are sufficiently novel, I believe, to require these introductory remarks, and it is my desire that these views may be fully and freely criticized.

I need not attempt to call your attention to the giant strides which have been made in the application of steam, hydraulic power, compressed air and electricity to the modern men-of-war since 1860. But the advance between 1860 and 1870 was not so great as that between 1870 and 1880, and that again was not so great as the advance between 1880 and 1890. What the advance will be between 1890 and 1900 I will not now attempt to predict, but of this we may be certain, that it will not be less than that made during the last decade.

But whilst enormous changes have been effected in the engineering

materiel of all navies, how very little change has been made in the engineering *personnel* to correspond with the change in the *materiel* and the altered conditions of naval warfare! And in this respect of engineer *personnel*, the progress of the United States Navy has not been in proportion to the development of the *materiel*. Yet for the past four years the steam department of the U. S. Navy has been presided over by the most energetic and most capable officer that has ever held the position of Engineer-in-Chief in any navy.

No one who has read the Annual Reports of the Chief of the Bureau of Steam Engineering can believe that the non-development of the engineer *personnel* is due to the absence of effort on his part. But, unfortunately, the dead past, old practice and ancient traditions still actuate all governments in dealing with their navies.

No naval war on a large scale has occurred to bring home to any government the importance of the engineer force on board ship. And yet scarcely a day passes that evidence is not forthcoming of the vital importance of the naval engineer, and that on him primarily rests the fighting efficiency of every navy.

As I retired from the British Navy upwards of four years ago, I do not think I can be considered guilty of boasting if I say that in my opinion the engineer department of the Royal Navy has been for some years as efficient as that of any other navy in the world. I may go still further, now, and say that at present it is more efficient than the engineer department of any other navy, because the English Admiralty has of late years very wisely increased the power of the engineer officers over the men and *materiel* of the ships actually afloat. Yet I do not hesitate to assert my complete conviction that the engineer branch of the British Navy is not even yet organized for efficiently discharging the duties which will be required of it in time of war.

Let me give one small example of those things which are occurring every day in all navies.

"On the 13th July last, during target practice on board H. M. S. Trafalgar, the locking bolt of the after turret was broken, and the turret was practically useless for three days, although the ship's artificers worked day and night at the repairs." Here we see one-half of the fighting power of a ship of 11,940 tons and 12,000 horse-power disabled for three days by the breaking of a single bolt. But if the breaking of a single locking bolt disables the half of the fighting power of a 12,000-ton ironclad, and the repairs of that defect require the labor of the whole of the ship's artificers for three days and nights, what may we

expect when a ship has been engaged for an hour with an enemy of equal fighting power? How many mechanics will be required to repair damages after one heavy shell has exploded inboard? This question is easy to ask, but not so easy to answer.

If two similar ships fight, and each receives similar injuries, so that they are compelled to separate for repairs, then if one of those ships carries, say, thirty mechanics whilst the other ship carries sixty mechanics, the latter ship ought to be repaired and in fighting condition first, and should most assuredly capture or destroy the ship carrying the smaller number of mechanics.

It may be argued that the number of mechanics cannot be increased without reducing the number of fighting men on board. That is the one great fallacy which has prevented the development of the fighting power of all navies. Skilled mechanics are of all men the most easily drilled to become good fighting men with rifles, heavy guns, torpedoes or pistols. And the drill necessary to make them effective combatants also improves them as mechanics. (See Appendixes A, B, C, D.)

But the question may be asked, How are these combatant mechanics to be employed on board ship during peace? My answer is: They would mount guard and do deck duty in lieu of the marines. There are in all armies corps of combatant or military engineers, and in all navies there should be corps of combatant naval engineers.

It takes some years to make a man an efficient sailor, and it takes some years for a boy to become an ordinary skilled mechanic. But the great civil war of 1861-5, and numerous other wars, have clearly proved that good soldiers can be speedily made out of intelligent men. The recent reduction of the period of training of the German soldiers proves how much can be done in these days in making soldiers out of fairly intelligent men.

There is plenty of enterprise, daring and love of adventure amongst the young mechanics of England and the United States, but they have a sentimental objection to enter the navy under the name, style or title of "coal-heaver" or "stoker 2d class," especially as there is no prospect of rising from those ratings to those of machinist, artificer, or warrant officer.

It has, therefore, been my desire for many years past that the whole of the naval engineer branch, from the engineer-in-chief to the newly entered coal-heaver, should be formed into one body to be called "The Corps of Naval Engineers." (See Appendix C, pages 50–52.)

It is not to be expected that good mechanics could be got imme-

diately to enter the navy in sufficient numbers to do duty as coal-beavers, and therefore the ratings of the engine-room men would have to be something as follows:

NAVAL ENGINEERS.

		Rank.
Fireman, 2d Class,	Fireman Mechanic, 2d Class,	Seaman, 3d Class.
Fireman, 1st Class,	Fireman Mechanic, 1st Class,	Seaman, 2d Class.
Leading Fireman,	Leading Mechanic, . . .	Seaman, 1st Class.
Chief Fireman,	Chief Mechanic, ...	Petty Officer, 3d Cl.
Machinist, or Artificer, ...		Petty Officer, 2d Cl.
Chief Machinist, or Chief Artificer, ...		Petty Officer, 1st Cl.
Assistant Engineers, ...		Ensign, or Sub-Lieut.
Engineers, ...		Lieutenants.
Chief, or Staff Engineers, ...		Lieut.-Commander.
Fleet Engineers, ...		Commanders.
Engineers-in-Chief, or Inspectors General of Naval Engineering, ...		Captain.
Director-General of Naval Engineering, . . .		Rear Admiral.

The oilers and water-tenders would not be separate ratings; the men for those duties would be selected from the chief mechanics and machinists. The pay of the fireman-mechanics, leading and chief mechanics, should be 25 per cent. more than the pay of firemen, leading firemen and chief firemen.

The above-named ratings of men and petty officers would comprise the engine-room men only. But the "Corps of Naval Engineers" under the control of the naval engineer officers should include the whole of the shipwrights, armorers, electricians, dynamo tenders, torpedo artificers, blacksmiths, plumbers and tinsmiths; and the whole of the *materiel* of the ship and all its arms and machinery should be entirely in the care of the engineer officers of the ship. (Appendix C, page 51.)

This UNIFICATION of the whole of the mechanics under the principal engineer officer of the ship would enable the whole of the mechanics to be concentrated on the repair of the most important defects, either of the ship, the propelling machinery, the gun mountings, torpedo machinery or electrical plant. And all the defects in all the *materiel* would be made good much more rapidly if there was a supreme head of the mechanical work, for then there could be no conflict of authority or friction, as there would be only one united body, instead of a large number of petty little departments to squabble about where each one's

authority begins or ends. The captain would hold the principal engineer officer responsible for the efficiency of the whole of the *materiel*, and the engineer officer would have the means and the power to sustain that responsibility. There would be a fair division of labor and responsibility. The captain and line officers would navigate and fight the ship, they would represent the nation, and deal with all international questions. The naval engineers would keep the *materiel* in repair, propel the ship, and fight as required, on board or ashore, under the orders of the captain or line officers.

I recognize as much as any man the difficulty of making a radical change in the *personnel* of such a conservative institution as the navy of any country is. But the statesman who is responsible for the organization of a navy should not be dominated by the ideas and practices of a dead past. His first and his last duty is to consider the efficiency of the navy for the hour of battle and for the week afterwards.

The naval organizer has to consider all sides of a many-sided question, and to determine the correct position and organization of the naval engineer corps he must study the position, duties and organization of the line officers.

The responsibilities of the captain and line officers are so great, it is necessary for them to know so much of a hundred things altogether outside of their ship, that they surely have no time to spare to play with hammers, files and oil cans in their endeavor to become practical mechanics.

It is necessary that the line officers should know the political state and condition of foreign countries, the state and tendency of commerce and local trade abroad, the condition of foreign navies, the strength or weakness of individual foreign ships, the capacity of foreign ports and the armaments of foreign seaboard fortresses, so that they may become broad-minded, capable, prudent but dashing naval commanders. Captains are not immortal, and in future wars the casualties may be so great that the command of ships may have to be taken by junior officers. How necessary is it then that the line officers should become acquainted with the most important portion of their duties—the duties of command—whilst the preservation and repair of the *materiel* is delegated to those officers who have a special aptitude and who have had a special training for the most efficient performance of those duties.

The duties of the executive or line officer are of such a varied and important nature that if they are to be properly learnt and properly performed those officers cannot have time to learn the details of engineering

as applied to steam propulsion, torpedo and gun fittings, electric light, etc.

The capacity of most men is limited, whether they be line officers, engineers or politicians. We have very old authority that there is "No royal road to learning." Yet not a few people on the European side of the Atlantic think it is only necessary to call a man a naval captain and then he instantly becomes endowed with a receptive capacity which will enable him to acquire as much knowledge of a difficult subject in five minutes as an ordinary man would acquire by five years' study and practical experience.

Not long ago a distinguished naval officer stated that the captain of a man-of-war should not only be able to order the engineer to repair a broken crank-shaft, but that the captain should be able to direct the engineer how to do it. Is this a specimen of modesty or of what? If ships had never been lost by bad navigation and worse pilotage we might imagine that the naval captains who belonged to the same navy as the speaker were very capable men who may possibly have sufficient time to study some practical engineering. But unfortunately ships have been lost by the ignorance and inefficiency of their captains and navigating officers, and before the executive officers occupy themselves with engineering it would be well for them to become perfect in their own special duties. Surely, if it were necessary for a captain to tell the engineer how to mend a broken shaft, it is only to be supposed that it would also be necessary for the engineer to tell the captain how to navigate and fight his ship. Such a confusion of duties would, however, be only fit for the inmates of a lunatic asylum. The engineer most assuredly should know better than the captain how to mend his broken crank-shaft, and the captain should know better than the engineer how to navigate and fight his ship.

There is no reason why the Engineer should not have as much zeal for his work, and feel as much patriotism and pride in the honor of his flag as any other naval officer; and there can be no doubt but that they are as much to be relied on to perform their duties as any other officers. But surely they must be fully trusted and given full control of all the machinery on board ship and full control of their own staff, otherwise it is impossible for them to perform their duties properly. In the British Navy, thirty years ago, the stokers were stationed at heavy guns, and received extra pay as trained men. At that time they were so frequently called out of the engine-room for gun and sail drill, cleaning copper on masts and sides, boat work, etc., that the engine-room work

was quite neglected, the men were overworked, and the engineer officers driven to despair. The state of affairs got so bad that at last the Lords of the Admiralty had to interfere and issue orders that the stokers should not be drilled or qualify for the rating of "trained man," and further stringent orders were given that the men should not be taken out of the engine-rooms without the knowledge and consent of the engineer officers. This was most beneficial to the engineer *materiel* of the British Navy as well as to the *personnel*. But that was when the engineer force formed but a small percentage of the total number of the ship's company; and, further, it was when the duties of the engine-room did not require such high skill and ability and such great physical strength and endurance as are required now. It is probable that the British Navy has more men engaged in tropical service for long periods than any other navy. And certainly the heat that the naval firemen have to endure in modern men-of-war is far in excess of the heat of the fire-rooms of the fastest mail steamers running in any part of the world. I well remember the chief engineer of an American steamer visiting my ship in the harbor of Acapulco. We had come into harbor the day before, our fires had been banked and we had windsails up and the ventilators trimmed to catch the breeze. After walking round the engine and boiler rooms that American engineer quietly remarked, "Well, you must have one consolation in this ship—you have not much to fear in the future, for whatever you do in this life, you can't get into a much hotter place in the next world than what you have got here." He further informed us that the maximum temperature of his engine-room when running from Panama to San Francisco was 27 degrees below the average temperature of ours.

I merely mention this to show one of the differences between the condition of men-of-war and merchant steamers. As years go on the differences become greater instead of less. And in my opinion it is absolutely necessary that means should be taken to provide healthier conditions for the engine-room mechanics and firemen on board men-of-war. This can be done only by giving them fresh air and daylight by spells of deck duty. They cannot have spells of deck duty and drill unless their numbers are largely increased. Their numbers cannot be largely increased if they are not drilled up for fighting purposes, otherwise the fighting power of the ship would be reduced; and therefore it is evident that for real fighting efficiency and for speedy repair of the ship after an engagement, the engine-room staff must be:—

1. So large as to be far in excess of the staff of a merchant ship of similar horse-power.

2. It must be in excess of the ordinary requirements of a man-of-war during peace time. Thus, if the present number of mechanics and firemen of a given ship be 100, then according to my views the number would be increased to 200, and the marines and idlers would be reduced by 100 men. The naval engineers for deck duty would therefore equal in number those employed below.

3. The deck party of engineers and the engine-room party of engineers would change duties every fortnight, say, on every alternate Monday at noon. The deck party thus becoming the engine-room party, and the engine-room party going on deck.

4. When steaming the engine-room party of engineers should never be called upon to do drill of any kind, or to do any deck work whatever. They should never be employed on any duty when off watch, and they should never be worked in the engine-room "watch and watch" for more than 24 hours.

5. When in port executing ordinary repairs, cleaning bilges, etc., the engine-room party should never be employed on deck or do drill of any kind until the engineer officer in charge has reported to the captain that the machinery is in all respects complete and ready for war service at a moment's notice.

6. When, owing to excessive heat or hard steaming in the tropics, etc., the engineer officer considers that it is necessary to increase the number of firemen in each watch, or to increase the number of watches from three to four, so as to give the firemen a "longer spell off," he will make written application to the captain for as many of the naval engineers from the deck party as he requires.

7. After an action or any disaster, when many defects may have to be made good, the engineer officer should make written application to the captain for the whole of the naval engineers of the deck party, as well as the engine-room party, to be placed at his disposal entirely until all defects are made good and the ship is once more ready for fighting. Until the defects are made good not a single man should be employed in drill or in doing any deck duty whatever.

On a former page I have referred to the numerous and important duties of the executive or line officers. Let me again refer to them. The executive officers in the British Navy are supposed to have a thorough knowledge of, 1, seamanship; 2, navigation; 3, nautical astronomy, meteorology, etc.; 4, marine surveying and compass correction; 5, pilotage; 6, gunnery, infantry drill, machine guns and field artillery; 7, torpedoes, automobile and stationary; 8, naval tactics; 9,

fortification, and other military subjects, such as transport and commissariat duties; 10, naval and military history; 11, international law; 12, foreign languages—French, German, Spanish, Italian.

In addition to these very necessary subjects, they are supposed to acquire a good knowledge of marine engineering and naval architecture, pure and applied mathematics, physics and chemistry. It is almost a matter for surprise that they are not required to have a profound knowledge of surgery, medicine, geology, mineralogy and theology.

Surely there can be no more necessity for the executive naval officer to spend his valuable time in studying naval engineering and architecture than there is for the skillful surgeon to study steel-making and the cutlery trade because he uses instruments made of steel.

Certainly if the executive officer can acquire a thorough knowledge of the twelve subjects above named, which are absolutely necessary for the efficient performance of his proper duties, the engineer officers may be trusted to be able to undertake the care, the management and repair of all the machinery, gunnery, torpedo and electrical fittings on board ship, and of the ship itself; and certainly the engineer officers should have control of the whole of the mechanics on board. Not only that, but the engineer officers should be drilled at heavy gun, rifle and battalion drill, so that they may be in full control of their men.

The number of engineer officers has been cut down very low in the British Navy and still lower in the U. S. Navy. I say they have been cut down dangerously low, because in war time a very slight accident may disable the two or three engineer officers and leave the engineer department entirely *headless*. And I can conceive nothing more dangerous than trusting the machinery of a man-of-war to the hands of mere mechanics, who have not sufficient scientific knowledge to utilize their own practical experience.

So far as the experience of the British Navy goes during late years, its efficiency has increased in proportion to the development of the engineer branch. The English Admiralty recognize this fact. For a long period I worked to get the engineer officers drilled, (see extracts from my letters to the British Admiralty dated 1877 and 1885 in the appendix) and at length an Admiralty circular, No. 17 N, was issued on the 11th March, 1886, ordering that leading stokers and stokers should be trained in the use of arms, etc. Furthermore, the engineer students were ordered to undergo a course of rifle, pistol, cutlass and battalion drill, and they proved themselves to be more than the equals of the other officers in smartness and proficiency in all drills. The great

ability shown by the engineer students in passing their examinations in torpedoes, gunnery and hydraulic fittings, electric light, etc., was a source of astonishment to the very able examining officers.

In concluding this paper, which only glances at some of the salient points of a large question, I would beg leave to state my conviction that the United States system of having an independent Bureau of Steam Engineering is by far the best that can be devised. But I am of the opinion that the Bureau should be heavily manned with good men, and that it should not be overloaded with work. The work of the Bureau should be divided into two branches:

1. The designing and manufacturing branch, having control over the work in the various navy yards and contract work.

2. The examining, testing, and *trustee* branch, whose duties it would be, first, to examine and report on the progress of the work at the various navy yards and contractors' works; second, to test the machinery, etc., on its completion, and to accept it or reject it according to its merits; third, to take charge of all new and old vessels and to keep them efficient (when out of the hands of the navy yards), and ready for active service at a moment's notice. This latter department would then act as an effective check upon the manufacturing department, which latter in some cases, in Europe at least, has been tempted to sacrifice efficiency for cheapness.

The officers of the examining branch ought to be senior to or of higher rank than the officers of the manufacturing branch. When the loss of H. M. S. Megara, in 1870, caused a committee to be appointed to inquire into the matter, I made proposals similar to the above; and at length this plan has been recently adopted by the Admiralty placing the steam reserve officers under the Admiral Commander-in-Chief at the various ports, instead of their being, as formerly, under the orders of the Admiral Superintendents of the various navy yards, who were *officially* the heads of the ship-building yards and engine factories.

As regards the charge of the machinery when it is on board ship, the whole of the hydraulic gear, the turrets, electric light, air-compressing machinery and torpedoes, torpedo-boats, steam capstans and steering engines is in the charge of the English naval engineer officers. The captain, therefore, has always a body of scientifically trained and practical mechanical officers to hold responsible for the efficiency of all the mechanical appliances on board. The hull of the ship also, as regards its interior parts, double bottoms, watertight doors and compartments, pumping and flooding arrangements, etc., are all in the charge of the

engineer department; and I maintain that no navy can be truly efficient for fighting purposes where this system is not fully carried out.

No half-and-half measures will avail. The executive or line officers must be the navigating and the fighting officers *par excellence*; they must have the control of the weapons and of the men who use them. But the engineers must have the sole care of the material and of the mechanical *personnel* to keep the machinery in fighting order, and to repair it after an engagement or disaster, and thus to prepare it for fighting again.

There must be no division of the mechanics on board, as at present, some under the carpenter, some under the gunner, and some under the engineer. All must be under the engineer if there is to be fighting efficiency.

So far the object of this paper has been to heap additional work, drill and responsibility on the engineer officers. I must now say something as to the necessity of bettering the conditions of the engineer officer's life. More than any other officer, the engineer requires good cabin accommodation, where he can rest at any time. For long periods I have had to keep "watch and watch," four hours on and four hours off, and so I have known what it is to require quiet cabin accommodation. Furthermore, all the engineer officers should be ward-room officers—that is, they should not mess in the steerage.

As regards title and relative rank, I cannot but think that as the English Navy has largely borrowed of the United States Navy in years gone past, so now the United States Navy may with advantage borrow from the English Navy somewhat. Thus the engineer officers on first entry for actual service afloat, after leaving the training college, should receive the title of "assistant engineer" with rank of ensign. After four years' service, and passing the necessary examination, the rank of "engineer" should be obtained with the relative rank of lieutenant. The next step would be that of chief engineer with relative rank of lieutenant-commander. And then the next step would be that of fleet engineer with relative rank of commander. The officers appointed to Dockyards and to the Navy Department of Washington should have the title of "engineers-in-chief," or inspectors-general of naval engineering with the relative rank of captain, and the chief of the bureau should receive the title of director-general of naval engineering and should bear the relative rank of rear-admiral.

FORMATION OF AN EFFECTIVE NAVAL RESERVE.

So far as I can see, no step has been taken to form an effective reserve of the engineer force for the United States Navy, so as to provide for a war with any great naval power. Whether such an effective reserve is necessary depends upon the foreign policy of the government of the United States. That it is necessary for the British Navy is, in my opinion, beyond all question, and the method I have proposed for the establishment of such a reserve is shown in the Appendix C, pages 52–55.

My aim has been to obtain efficiency for the hour of battle and for the week afterwards, and that object I pursued during the time I was in the English Navy; and it is still my object, although I have no personal interests to serve, as I have neither relatives nor friends in any navy. I know that my views are not approved by many officers of all classes. On the other hand, I know that many officers who have seen some sea fighting agree heartily with these views.

I say there is in these days no room on board a modern man-of-war for the man who is only a marine and nothing more, or only a fireman and nothing more, or only a mechanic and nothing more. Whatever he may cost to obtain, the man for the naval engine-room must be a stoker, mechanic, marine gunner, similarly as the English man-of-war sailor is a seaman, a gunner, a rifleman, a torpedoist and a diver.

I can only hope that these few remarks will be amply discussed and receive the severest criticism of the members of the Institute, and that those that do me the honor to oppose my views will remember that I write not for the piping times of peace and fair weather cruising, but for THE HOUR OF BATTLE AND THE WEEK AFTERWARDS.

APPENDIX A.

EXTRACT FROM LETTER BY GEORGE QUICK TO ADMIRALTY, DATED ——, 1877.

ENGINEER SERVICE OF THE ROYAL NAVY.

Suggestions:—*Engineer Students.*—The present method of educating the students in mechanical skill and pure mathematics is all that can be desired, but I think from my own knowledge of many of those who have been students that more time and attention should be given to drawing and physical science than at present.

Drill.—There is, however, another point of great importance to which I have never seen any allusion made; that is, that for the due performance of his duty it is necessary that the engineer officer should at an early age acquire some idea of command, not of a ship, but of the men under his control. To give that idea of command there is, in my opinion, no method of education so effective as military drill.

I venture, therefore, to suggest that a portion of time should be devoted every week to the instruction of the students in rifle, cutlass and heavy gun drill, even if the time of study has to be increased by six months—that is, from six years to six years and a half; although I do not think that is absolutely necessary, as I am of opinion that the term of mere mechanical labor in the workshops might be reduced with advantage, for from my experience of the service I am led to conclude that a military spirit and officer-like feeling would tend to the preservation and proper use of the machinery of the fleet far more than any manual skill in mechanical labor possessed by the persons in charge of it.

With engineers having a military spirit and officer-like feeling, there would be every exertion made to preserve the machinery in the best working order. It is the prevention of the necessity for repairs, combined with the capacity to effect repairs after an action, in the shortest time, that constitutes the highest art of the seagoing naval engineer officer.

The proposed system of drill would also induce a more systematic routine in the engineer department than is general at the present time. And in the event of large numbers of the combatant officers being disabled in action, ashore or afloat, sick or absent in the vessels taken from the enemy, landing parties, etc., the engineer officers would be available for directing, under the orders of the commander of the ship, the mechanics, stokers and domestics, whom I suggest should also be trained to the use of small arms.

Drill of Mechanics, Stokers and Idlers.—Taking into consideration the very large proportion that the mechanics, stokers and other civilians bear to the pure blue-jackets and marines in modern ships of war, it appears to me necessary that so large a number of persons should receive some instruction in rifle, cutlass and gun drill.

If the plan suggested be carried into effect I believe it will positively increase the efficiency of the men in the performance of their ordinary duties, for there can be no doubt but that military drill, teaching the habit of physical obedience to the word of command, is of great benefit physically to all who are brought under its influence.

APPENDIX B.

EXTRACT FROM LETTER BY GEORGE QUICK TO ADMIRALTY, DATED NOVEMBER, 1885.

ENGINEER OFFICERS.

1. Having regard to the vast increase in the power of the machinery of modern ships, and the greatly increased range of the duties and responsibilities of the engineer officers, and the large number of men under their control, I am of opinion that there is an urgent need for a considerable change in the rank of these officers.

From the Navy List of the 1st October, 1885, it appears there are now of ships built and building 92 vessels of 3,000 indicated horse-power and upwards, with engine room staff of from 32 to 118 men, exclusive of engineer officers. This gives an average of 5,925 indicated horse-power and of over 69 men under the control of every chief engineer of these ships. The total power of these 92 ships is upwards of five hundred and forty-five thousand indicated horse-power for propelling engines alone, exclusive of all the numerous auxiliary engines for steering, hoisting purposes, electric light, turret work and torpedo machinery. Or, excluding all ships under 4,000 indicated horse-power, there remain 73 ships of an average of 6,600 indicated horse-power and with an average engineer staff of over 75 men.

For the control of this vast total of more than half a million of indicated horse power of machinery and of upwards of six thousand four hundred men there were on the 1st October last on the active list of the Navy (excluding inspectors of machinery) only 19 officers of the relative rank of commander, and none of the relative rank of lieutenant of over 8 years' seniority, all the other chief engineers on the list except the above mentioned 19 being junior to lieutenants of 8 years' seniority.

Such a scarcity of officers of the relative rank of commander does not exist in any other branch of the public service, regard being had to the total number of men belonging to the department, to the enormous money value of the material under the control of these officers, and to the vast importance of the duties of the department from a purely fighting point of view.

In modern warfare the breakdown of the engineering department during action means the total loss of the ship.

2. That the Navy has hitherto existed without engineer officers

holding higher rank than they do is no argument in favor of their retaining their present low position. For, in fact, the number of engineer officers in the relative rank of commander was much larger in years gone by than it is now, or than it is ever likely to be again under the existing regulations. For, in the course of a few years when all the engineer officers of the rank of engineer will be qualified for the rank of chief engineer, the rate of promotion to the rank of chief engineer will be much less than it is now; and few engineers will be promoted before arriving at 44 to 45 years of age. I have not the slightest doubt but that the engineer department is quite as efficient as any other department in the Navy (if not much more so), and that it is far more efficient than the steam department of any other navy in the world; but I am of opinion that it could be made very much more efficient for combatant and all other purposes by the changes I shall propose to be made.

3. I have no hesitation in asserting that the very small improvements which have been made during the past 8 years in the position of the junior engineer officers have been productive of great benefits to the efficiency of the service, and I am confident that any other improvements which are made in the position of the engineer officers generally will be amply compensated by a further increase in efficiency. It is very certain that the duties of the stokers are of the most arduous and disagreeable nature, very trying to the health, temper and discipline of the men. There is no romance or interest in shoveling coals in the bunkers or into the furnaces, nor in cleaning boilers, bilges, etc., like there is in the blue jacket's work on deck. And the management of the men under these circumstances is very frequently a most difficult task for the engineer officer of the watch, or the one who has charge of the men for the day. I cannot but speak in terms of the highest praise of many of the stokers I have known, men who have worked hard, were careful and cautious in the performance of their duties, strove to improve themselves as workmen, and gave no trouble to the engineer officers. But I have known many other cases in which the stokers have given an immense amount of trouble to the engineer officers, whilst they were cunning enough to keep a good "deck character" by not breaking their leave and by being very obsequious to the ship's police. It has been, as a rule, very difficult to get such men punished for crimes in the engine-room, because their good "deck character" saves them; and then, when it begins to be understood that the engineer officers cannot get the men punished for engine-room offenses, discipline and

ready obedience in the engine-room are very difficult to maintain. I know one case in which an engineer officer having reported a stoker for having been asleep when on duty, the unfortunate officer was accused of neglect of duty in allowing the man to go to sleep, but the stoker was not punished. This decision led to much insubordination amongst the other men, and it was not until another engineer officer had laid a complaint before the Admiral on the station and obtained satisfaction that matters began to go on in a satisfactory manner in that ship's engine-room.

During a time of peace when only ordinary cruising duties have to be performed the maintenance of discipline is, as I have endeavored to show, in some cases very difficult; and it appears to me that in action and in times of great danger it may be, in some cases, utterly impossible for discipline to be kept, if the engineer officers have not higher rank and greater legal control and power over the men than at present.

In two cases of imminent peril that I know of, the stokers remained in the stokehold doing their work quickly and quietly; but, in two other cases I have heard of, the engineer officers had to prevent the men by force from bolting up the ladders to get out of the engine-room and stokehold.

4. This brings me to an important point as to the training of stokers and engineer officers. The immense influence of military drill upon men generally to improve their discipline and to make them better workmen in all occupations of life is strikingly shown by the superiority of the man who has been a marine or in the army, when entered as a stoker, to the ordinary men who are entered as stokers without any military drill. I have for many years noticed this, and having regard to the very large number of stokers and other undrilled and unarmed persons on board English ships of war, I have endeavored to get a certain amount of military drill for the stokers *on first entry into the service*, and some little practice of the same kind afterwards at sea.

If this were done there would be less objection to the engine-room staff of stokers being increased in numbers. That it would improve their discipline and their work in the engine-room I am also completely convinced by what I have learnt from French and German manufacturers and large employers of labor, of the vast improvement in the character and conduct of their workpeople since the institution of compulsory military service in those countries.

5. The duties of the engineer officers as well as of the stokers have become of a far more combatant nature than they were formerly; and

I consider it is most desirable that the junior engineer officers should be required to undergo a course of military drill.

This is no new idea of mine, as I drew up a paper on the subject in 1877-8 for Admiral Moresby, who was then captain of H. M. S. Endymion. But it was not popular with the engineer officers nor with stokers a few years ago. A great change of opinion on this point has, however, taken place, I believe, and I have been told by stokers who have been employed in torpedo-boats, etc., that they felt very strongly they ought to have instruction in the use of arms to defend themselves, and that arms ought to be supplied to them. They also said that they thought they ought to be taught at least how to discharge the torpedoes, in case all the deck people of the boats should be killed or disabled. I do not think it is desirable to attempt to make men "Jacks of all trades," but as modern warfare requires so many mechanical operations to be performed, I am decidedly of opinion that the whole engineering staff should have a certain amount of drill in the use of arms. It has been proved by experience that as a rule the well-drilled man (soldier or sailor) will make a good workman, and it has been equally well proved that the good workman will drill well and quickly and make a very good shot. Cleaning and polishing brass work on deck I do not consider as drill, and stokers should not be employed at such work unless the complement of stokers be largely increased.

6. Up to the present time engineer officers have been "civil" officers. I am of opinion that the time has arrived when they should be made military officers, similarly as the navigating officers are, and that they should wear similar uniform to the navigating officers, but with the distinguishing marks of the engineer officer as regards velvet between stripes, etc.

This change of uniform alone would largely increase their power and authority over their own staff in the engine-room; but I am of opinion that the principal engineer officer on board a ship should have the power of awarding minor punishments to his men direct, or at least of bringing the men directly before the captain instead of bringing them as now before the first lieutenant or commander.

This removal of the engineer officers from the civil to the military branch is the greatest change I have to propose. It has been recommended before by an Admiralty Committee, and I know that a very large number of the engineer officers are desirous of it solely for the purpose of obtaining increased efficiency in the engineer department.

7. Whether the engineer officers are removed to the military branch

or not, I consider it is most desirable that the following alterations in the titles and in the relative rank of the engineer officers should be made:

1. That the head of the engineer department at the Admiralty, whether the appointment is held by a civilian, as at present, or by a naval engineer officer, should receive the title of "Director-General of Naval Engineering" or "Director-General of the Engineer Department of the Navy," and that he should, if a naval engineer officer, hold the relative rank of rear-admiral, whilst holding that appointment.

2. That the titles of chief inspector of machinery and inspector of machinery be abolished, and that the officers now in those ranks should receive commissions as "engineer-in-chief" with the relative rank of captain in the Navy, according to date of commission. The seniority of these officers to date from the date of their first commission as "inspector of machinery." Thus if an officer was promoted to the rank of inspector of machinery in 1875 and to chief inspector in 1880, then his seniority as an "engineer-in-chief" would date from 1875.

The number of "engineers-in-chief" should be 12, and they should be appointed for service as follows: One for each reserve at Portsmouth, Devonport, Chatham, Malta (4). One for each dockyard at Devonport, Malta, Bermuda, Hong Kong, Halifax, Cape of Good Hope (6), and 2 others available for employment on special service, at the Admiralty, or in large fleets, or otherwise as required.*

3. That all chief engineers now on the Active List, of and above 7 years' seniority, should receive commissions as "fleet engineers" and have relative rank with commanders in the Navy according to date of commission.

Those few "chief engineers" who now rank with commanders to have their commissions as "fleet engineer" antedated, so as to give them the same seniority relative to commanders as they have at present. Thus the seniority of the present senior chief engineer in the Navy would be dated as "fleet engineer" the 27th September, 1881.

*Those officers who are now Chief Engineers of the Dockyards at Portsmouth, Chatham and Sheerness must, in the course of a few years, become "inspectors of machinery" on the present system, or "engineers-in-chief" on the proposed system. I am of opinion that it would be of advantage that the officers now holding those appointments should have the rank of "engineer-in-chief" conferred on them immediately.

I am of opinion that the principal engineer officer of every ship of 3,000 indicated horse-power and upwards, or which has an engine-room complement of 40 men and upwards, should not have a lower relative rank than that of commander. As there are 92 of such ships built and building, and as this number is likely to be increased, I am of opinion that there should not be less than 100 engineer officers of the proposed rank of "fleet engineer." These would be employed somewhat as follows:

For ships built and building of 3,000 I. H. P. and upwards .	80
For the Admiralty	2
For reserves at Portsmouth, Devonport, Chatham (3 at each)	9
For dockyards at Portsmouth, Devonport, Chatham and Sheerness	9
For dockyards at Gibraltar, Jamaica, Esquimault	3
For Victoria and Albert and Osborne Royal yachts . . .	2
	105

From the foregoing it is evident that there will be plenty of appointments open for the proposed number of "fleet engineers." This rank of fleet engineer should be granted:

(*a*) To those officers who have 7 years' seniority as chief engineer and 20 years' total full-pay service in all ranks.

(*b*) To those chief engineers who have two years' full-pay service as such, and shall have distinguished themselves in the presence of an enemy, or for conspicuous professional merit, such promotions to be "special" and not to exceed the rate of two in any one year after the first year of the introduction of the rank of fleet engineer.

(*c*) The total number on the Active List at any one time of the fleet engineers holding that rank by such special promotion shall not be more than 20.

(*d*) The Admiralty to have the power during the first year of the introduction of the rank of "fleet engineer" to give ten special promotions to that rank.

(*e*) As a rule two or more fleet engineers should not have seniority of the same date.

(*f*) The Admiralty to retain power to specially promote chief engineers to the rank of "engineer-in-chief" for very distinguished service in the presence of an enemy, or for great professional merit and services, similarly as they have at present; that is, after five years' service as chief engineer.

8. In order to have one uniform title in the navy to indicate or distinguish one particular degree of relative rank throughout all branches, I have to propose that those "chief" engineers on the Active List who may not be immediately promoted to the rank of "fleet" engineer should receive commissions as "staff" engineer with the relative rank of "staff lieutenant" according to date of commission. The date of the seniority of the "staff" engineers to be that of their present seniority as "chief" engineer. Thus a chief engineer whose seniority is, say, 1st July, 1882, would become a "staff" engineer with seniority of 1st July, 1882.

9. *Engineers.*—The position of the engineer officer of the rank of "engineer" requires to be greatly improved. As previously shown, there are 92 ships built and building of 3,000 indicated horse-power and upwards, and with engine-room complements of from 38 to 112 men, and there are 83 ships of under 3,000 indicated horse-power and over 1,000 indicated horse-power.* It appears to me of the utmost importance that at least the two engineer officers next in authority to the principal engineer officer of a ship of over 4,000 indicated horse-power should have the relative rank of lieutenant with seniority according to date of commission, and that the engineer officer in charge of small vessels under 1,000 indicated horse-power should also have the same rank. There can be no doubt that the duties and responsibilities of engineer officers are increasing more rapidly than those of any other class in the service.

I have, therefore, to suggest that all engineer officers now on the Active List as "engineers" should rank with lieutenants under eight years' seniority according to date of commission. They would thus be always junior to staff lieutenants (if that title be adopted) or to lieutenants of eight years' seniority. The number of officers required for the service must be determined by the number of ships built and building. At present, I believe that about 300 engineer officers of this rank of "engineer" are required for active service.

10. *Assistant Engineers.*—All assistant engineers of whatever age or length of service are, according to the present regulations, junior to sub-lieutenants and all assistant paymasters. This is felt by them to be a very great hardship, and I am of opinion that assistant engineers should rank with sub-lieutenants according to date of commission.

*With engine-room complements of 55 men and under; and there are 166 vessels having less than 1,000 indicated horse-power.

APPENDIX C.

EXTRACTS FROM PROPOSED ORGANIZATION OF A COMBATANT CORPS OF ROYAL NAVAL ENGINEERS, WITH AN EFFECTIVE RESERVE OF NAVAL OFFICERS AND MEN, BY GEORGE QUICK, FLEET ENGINEER, DATED 29TH JANUARY, 1887.

DISCIPLINE AND DRILL OF THE STAFF OF THE STEAM DEPARTMENT.

From the Navy List of 1st October, 1886, it appears there are now one hundred (100) ships, built and building, of 3,000 I. H. P. and upwards, with engine-room staffs of from 29 to 119 men, exclusive of officers.

This gives an average of over 70 men, under the control of the engineer officer of each of these ships; and an average of 6,222 I. H. P. for propelling engines, exclusive of all other kinds of machinery. The total number of men in the engine-room staff of these ships is 7,066.

Besides these men, there are many others not classed as combatants, such as armorers, blacksmiths, carpenter's crew, plumbers, etc.

Having regard, therefore, to the large number of unarmed and undrilled persons in our ships of war, forming as they do so large a proportion of the ship's company, we would recommend that all these so-called "idlers" should be exercised in the use of rifle, pistol and cutlass; and also in the case of artificers and stokers at heavy gun drill, instead of their valuable time being expended in sail drill, as at present.

The immense influence of military drill to improve discipline and make better workmen is strikingly shown by those men who have been marines, when entered as stokers, compared with the ordinary men entered. That it would improve the discipline and woik in the engine-room is undoubted.

The duties of stokers are of the most arduous and disagreeable nature, very trying to health, temper and discipline, and their management by the engineer officers is often a difficult task, even in times of peace; in action, and in times of great danger, it may be utterly impossible for discipline to be maintained, unless the engineer officers be given greater legal control and power over them. More especially is this apparent when we consider the conditions under which a future naval action would be carried on, so far as regards the engine-room department; with all water-tight doors in engine-rooms and stokeholds closed, the stokeholds under forced draught, necessitating the securing down of all

hatches, the only communication with the executive officers being by means of a voice-tube to the bridge or conning tower.

It is therefore necessary that the principal engineer officer should have the power of awarding punishments of a minor nature to the men of his department, and referring graver offenses to the captain, instead of laying every little complaint before the senior executive officer as at present. The junior engineer officers should also be instructed in heavy gun drill as well as in rifle, pistol and cutlass drill in order to exercise their own men, so that the engineer officers might, under the direction of the captain, have over their own staff similar control to that exercised by the executive officers over the seamen.

Moreover, in the case of future warfare, it is reasonable to anticipate that some of the enemies' ships would be captured. Such ships would either have to be destroyed, or prize crews placed on board to take them to a British port. Such crews must necessarily contain a large proportion of officers and men of the steam department, which could not be arranged, under existing circumstances, without crippling the fighting power of our own vessels.

This consideration points out the necessity of largely increasing the proportion of ranks and ratings of this department, in the complements of our men-of-war. In times of peace, this increase of numbers might partly be employed with advantage in their usual duties, the present complements being, in many cases, barely sufficient to maintain the efficiency of the department; but in order to usefully employ the whole of such increase, it would probably be found necessary to detail them for other duties. It is therefore thought that the exceptionally good conduct of the engine-room staff, under the ordinary circumstances of the service, justifies the experiment being made of forming a part of the "guard" of trained stokers, instead of Royal Marines. By thus relieving a portion of the engine-room staff of the confinement entailed by their ordinary duties, and giving them more open-air exercise, the effect on their health would be most beneficial.

THE FORMATION OF THE WHOLE OF THE ENGINE-ROOM STAFF AND SHIP'S ARTIFICERS INTO ONE BODY FOR THE MAINTENANCE AND REPAIR OF THE SHIP.

Within the last fifteen years the battle-ships of the Navy have undergone vast changes in their construction and armament, more especially as regards the number of fighting machines fitted on board, such as breech-loading guns and Vavasseur gun-carriages; torpedoes with

above-water and submerged discharging tubes; torpedo pressure pumps and air reservoirs; electric lighting machinery, both for search lights and internal lighting; hydraulic engines for revolving turrets, and hydraulic loading gear for the guns; also steering and capstan engines and ventilating machinery.

For the preservation and repair of these machiues there are various ratings of artificers, some under the direction of the gunnery officer, some under the torpedo officer, and others under the engineer officer, whilst there is the carpenter's crew for the repair of the hull.

But where there is such a divided responsibility as at present, it is impossible that the work can be carried out, and repairs executed in a thoroughly practical and efficient manner, especially as neither the gunnery nor torpedo officers have received any practical mechanical training. Neither can this machinery be kept in a thoroughly efficient state at the smallest possible cost, under existing circumstances; for, in order that the work done by these artificers may be efficiently carried out, they should be under the supervision of officers who have received a thoroughly scientific and practical training, and who can, when necessary, show them how the work should be done.

In order, therefore, to combine the efficiency and economy in utilizing this large staff which is essential to the thorough efficiency of our fighting ships, it is necessary that the whole of the artificers of all classes—armorers, blacksmiths, plumbers, shipwrights, stokers, tinsmiths, lamp trimmers, etc., (except coopers)—should be merged into one body under the engineer officers,* and forming the corps to be called the "Royal Naval Engineers;" the different ratings therein, with the various rates of pay, to be retained as at present, or be modified in such manner as may hereafter be determined by the Board of Admiralty.

The engineer officer of the ship should be held solely responsible to the captain for the preservation and efficient working condition of the whole hull, engines of all descriptions, guns, gun carriages, hydraulic gear, torpedoes, torpedo gear, electric light, and all other mechanical appliances on board, and for all spare gear and stores appertaining thereto.

By thus placing all stores under the charge of the engineer officer, needless duplication would be prevented, and a reduction obtained both in the weight of stores carried and in the space occupied, together with simplification of the store accounts.

*There is no doubt that if this large staff were placed at the disposal of the engineer officers, the number of defects from ships in commission required to be made good at the dockyard would be largely reduced.

It is considered that by conferring the name, style or title of "Royal Naval Engineers" on all the artificers, mechanical workmen and stokers in the Navy, it would be a very great inducement to smart and able young mechanics to join the service in much larger numbers and for the present rates of pay. This view is confirmed to a great extent by the class of men found willing to join the corps of Royal Engineers.

It is also desirable to establish the rating of "mechanic writer," who should be capable of keeping accounts and writing a good hand; one or two being included in the complement of each ship (according to size), and thus relieving the engineer officer of much clerical labor, and enabling him to devote greater attention to the personal supervision of his staff. All men of the corps, possessing the necessary qualifications, to be eligible for this rating.

PROPOSALS FOR THE FORMATION OF AN EFFECTIVE RESERVE OF ENGINEER OFFICERS.

In 1870 Mr. Childers, who was then First Lord of the Admiralty, abolished the reserved list of executive officers as being utterly useless, and made them all retired officers.

Yet, an efficient reserved list is required, and the formation of one is not an unsolvable problem if a sufficiently broad view be taken of the subject and of the requirements of the Empire. Indeed, the institution of this reserved list of efficient officers of moderate age is, in the case of the engineer officers, an Imperial necessity. In the "Royal Naval Reserve" there are only two engineers (their commissions bearing dates May, 1865, and February, 1882). In 1877, when there was a large demand for engineer officers and artificers to man the reserve fleet, it was found almost impossible to obtain them; and although some officers were obtained from the mercantile marine and the large engineering firms, they would have been of little use at sea until they had gone through a long course of training on a modern man-of-war. If war were actually declared against any great naval power, or combination of naval powers, few merchant service engineers would be found to join,* and, if they did, they would be comparatively useless owing to their want of training.

And although we have on the retired list 180 chief engineers and 200 engineers and assistants, these can in no sense be considered an

*In time of war all sailing merchant ships would be laid up and only steamers employed; consequently there would be a very heavy demand for the services of every seagoing engineer in the mercantile marine.

effective reserve; because, when an officer is retired, he, as a rule, keeps up neither his knowledge nor his interest in the service; and those who have been on the retired list for upwards of two years, without practical experience, are in these rapidly moving times nearly, if not quite, useless, it being necessary for officers to keep constantly in touch with the service to retain their efficiency.

Furthermore, the coast defenses of this country are in a most unsatisfactory state; and any satisfactory scheme for the reorganization of our coast defenses must include, for the service of each station, one or two torpedo-boats, mines for the defense of harbors, etc. The Royal Naval Engineers would be admirably suited for this work,* both for the care and maintenance of the material and for the instruction of men in the reserve and of the naval volunteers.

The establishment of the "Effective Reserve List"† could be easily brought about by the following arrangements, which would give the additional advantage of creating a healthy flow of promotion on the active list, as many officers would willingly go into the "executive reserve" who would not go on the retired list, and thus sever their connection with the service altogether:

1. Entry on the effective reserve list to be by permission of the Admiralty only, and not to be claimed as a right.

2. Officers to be eligible for the reserve list at the following age:

Rank.	Lowest age for permission to enter Reserve.	Age for retirement from Reserve compulsory.
Engineers	35 years.	55 years.
Chief engineers, staff engineers	40 "	60 "
Fleet engineers	45 "	60 "

3. Officers on the reserve list may, on their own application, and by the consent of the Admiralty, be transferred to the retired list at any time before arriving at the age for compulsory retirement from the reserve list.

4. Officers on the reserve list who may be incapacitated for the performance of the active duties of the service shall be retired by direction of the Admiralty as their Lordships may see fit in each case, so that the reserve list may be kept really efficient for active service.

*The French have organized a corps of naval engineers for service on shore, for the purpose of torpedo coast defense, etc.—*See Lord Brassey's "Naval Annual," 1886, p. 479.*

†Invalided officers would not be admitted to the "Effective Reserve List."

5. No promotion to be given to officers on the reserve list, except for war service or active service afloat.

6. Officers on the reserve list to attend at one of the naval ports for a period of two months every two years for practice in naval duties, and to receive information or instruction in new naval appliances, etc.

7. The number of officers on the reserve list to be as follows, and to receive the retired pay due to their age and service, all junior time being allowed to count, together with an allowance of reserve pay at the following rates:

No.		Rate.			Amount.
200	Engineers	at 2s.	per diem	=	£7,300
70	Chief and staff engineers .	" 2s. 6d.	"	=	3,194
30	Fleet engineers	" 3s.	"	=	1,643
300		Annual cost of reserve .		=	£12,137

Average for each officer per annum, £40.

8. Officers on the reserve list to receive while serving at a naval port a subsistence allowance of 3s. per diem, in addition to the above.

9. When officers on the reserve list are employed afloat on actual service they shall receive the full pay of their rank, and will count all time so served for increase of full, half, reserve and retired pay.

10. Officers on passing from the reserve list to the retired list to count half the time served on the reserve list for increase of retired pay.

In consequence of the officers on this reserve list being really effective and available for active service afloat, all costs should be charged to the votes for effective service.

PROPOSALS FOR THE FORMATION OF AN EFFECTIVE RESERVE OF ENGINE-ROOM ARTIFICERS AND STOKERS.

1. All petty officers and men who have completed their service for pension to be medically examined to ascertain their fitness for future service, if required.

2. All petty officers and men found physically fit to be passed into the effective reserve, and remain therein until attaining the age of 55 years, unless they should be found to have become unfit for active service before attaining that age.

3. All petty officers and men of the effective reserve to be placed in three divisions, as nearly as possible equal in numbers.

4. One division of the effective reserve to be called up for exercise and training in the special duties of their service ratings for a period of

two months in every year, preferably from the middle of May to the middle of July, so as to be employed in the reserve squadron during the summer cruise, instead of men being drawn away from the steam reserve as at present.

5. If there be more men in the division of the effective reserve called out than can be usefully employed in the reserve squadron they should be employed in the steam reserves at the principal naval ports.

6. The petty officers and men of the effective reserve should all as far as possible be employed on the special work to which they have been previously trained, and according to the ratings held at the time of their being pensioned.

7. During the time they are called out for training the petty officers and men of the effective reserve should receive the full pay of their ratings and free provisions, in addition to their pensions.

8. In consideration of being formed into an effective reserve, and having to keep a sea kit always ready for immediate service, an allowance of reserve pay, in addition to pension, to be received according to the following scale:

Chief petty officer	4d. per diem.
1st class "	3d. "
All other ratings	2d. "

The charges for provisions and pay in excess of the men's ordinary pensions to be charged to the votes for effective service.

APPENDIX D.

EXTRACTS FROM LETTER SENT BY GEORGE QUICK TO THE ADMIRALTY, 1891.

I beg leave to call the attention of the Lords of the Admiralty to the desirability of forming a corps of Royal Naval Engineers, to be composed of skilled mechanics, for the performance of engineering and stoking work of the navy, and to do guard and deck duty also, in place of the Royal Marines.

It is impossible to overestimate the importance of the speedy repair of the machinery of ships of war after an action, for the gaining of only a few hours in effecting repairs after a battle may decide most important naval operations following upon either a slight or severe engagement.

It is not a good argument to say that English ships will carry as many artificers or mechanics as foreign ships, and that consequently there is

no need to increase the staff of mechanics on board our ships. For if two similar ships engage and each receives similar injuries so that they are compelled to cease fighting and withdraw for repairs—then if one of those ships carries say only thirty skilled mechanics for effecting repairs, whilst the other carries sixty mechanics, the latter ought surely to be in fighting condition first, and must assuredly capture or destroy the former. The naval battles of the future must be in the hands of the seamen-gunners and the drilled firemen-mechanics, for there is no room for or need of the marine on board a modern man-of-war. It is not possible to teach marines in a year or two to become useful mechanics or good firemen and to drill them very quickly into doing all the military duties of marines on board ship. Such a change could not be effected suddenly, but as I advocated the drilling of stokers and engineer officers more than thirteen years ago (and which was adopted only within the last six years), so now I advocate the extension of the system, as the sooner it is adopted the better it will be for the navy.

In the ships of the present day there is no room for the man who is only a "stoker" and nothing more; nor is there room for the "marine" who is only a soldier and nothing more; nor is there room for the man who is a "mechanic" and nothing more.

But what is wanted is the man who can be a fireman, mechanic and marine all in one, and I maintain that such a man can be made if my proposals be adopted, and that there will be but little difficulty in obtaining capable recruits in large numbers if their prejudices or sentiments are duly considered.

I have written on this subject for many years, and on the 29th of January, 1887, I forwarded officially to the Admiralty, through the Commander-in-Chief at Devonport, several copies of a pamphlet on this subject. On page II of that paper it is stated that "It is considered that by conferring the name, style or title of 'Royal Naval Engineers' on all the artificers, mechanical workmen and stokers in the Navy it would be a very great inducement to smart and able young mechanics to join the service in much larger numbers than at present, and for the present rates of pay."

Since my retirement in 1887 I have had many opportunities of ascertaining the feelings of a large number of young mechanics in all parts of the country, and I have found many of them express a strong desire to see the world by taking service in the Royal Navy for a few years as "Firemen Mechanics," providing they were called "Engineers," and providing they had a chance of promotion in case they wished to remain in the Navy.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE SIGNAL QUESTION UP TO DATE.

By Ensign A. P. Niblack, U. S. Navy.

In a recent number of the Proceedings the writer made a futile attempt to solve some of the difficulties of the naval signal question, by proposing a system of day, night and fog signals conforming to the requirements of the American Morse code, adopted some two years ago as the service code; but any attempt to patch up the defects of that code, as applied to naval purposes, is a foredoomed failure, because it possesses just those undesirable qualities which every consideration of theory and practice condemns. The substitution of the English Morse code for the Myer was not regarded as successful, as it seems to have been dropped in turn for the American Morse. This last named was adopted by the Navy Department at the request of the Chief Signal Officer of the Army, in order that the two branches of the military service might communicate in emergencies. The principal reason which led the Army authorities to adopt the American code was, that it being the commercial code, in time of war skilled operators would be abundant from which to recruit the Signal Corps. That reason at least has no bearing on the question from a naval standpoint, for in time of war if there is anything more than another that is not wanted aboard ship it is a landsman with only one talent, and that for working a key. In accepting this allurement, however, the Army authorities left out of consideration the fact that in time of peace, especially now that enlisted men can purchase their discharge, the current is reversed, and the expert signalmen of the Army furnish an inexhaustible source of supply to the commercial demand for telegraph operators. In the Navy we had some such experience with seaman gunners as expert electricians, until the course at Newport was changed. Whether or not the Army author-

ities have made a mistake concerns us only in that if we are to be saddled with a code not adapted to our purposes, and ages behind the times from a naval standpoint, just because the Army has adopted it, then the sooner we can compromise with the Army authorities the better. As it is now we have a code which possesses the sole recommendation that in some remote emergency we can communicate with an Army station. It does not take much cleverness to see, however, that this very desirable thing could be accomplished by requiring only the signal officer and signal men of each ship to know the American Morse code for just such emergencies; but why require the whole Navy for years and years to use it, with all its glaring defects, when the solution is so simple?

The American Morse code is not adapted for naval purposes:

1st. On account of the space letters *c*, *o*, *r*, *y* and *z*, and in the character *and*. The space is bad in the wig-wag, for in the recovery from a *front*, representing the space, it is made so quickly that unless the signal sender is facing squarely (and often he cannot be, in communicating, say, with two adjacent ships or stations at once) it is difficult to distinguish this quick *front* from a dot or dash, as the case may be. In night flashing with winker lights it requires an extra light to make the space signal, or else the use of a very long dash, which is confusing and wastes time. In a display of red and white lights, like the Ardois system, a third color (green) must be introduced, as was attempted in a system proposed by the writer in a recent Proceedings, which plan as there proposed is acknowledged to be a failure. Anything which attempts to utilize the American Morse code is, however, bound to more or less of a failure. In fog signals the space must be indicated by a long dash, which may lead to some confusion, but at any rate wastes valuable time. If these reasons are not enough to condemn the American Morse code for naval purposes, then:

2d. The character *error* is, in this code, seven dots; the numeral *six* is six dots; the letter *p* is five dots. Even if we get around the *error* by substituting some device, still, in some such system as the Ardois, by which all the elements of a character are exhibited in one display, we must have at least six lanterns in the permanent hoist with which to make the numeral *six*. When the Navy Department ordered the eight Ardois apparatus from abroad, a plan of the sixty-four sectors was furnished the makers by which to mark the disks of the signal boxes. It was found impossible to use the American Morse

code, not only on account of the requirements of the *error* and the *six*, but of the impossibility of displaying the space letters. Accordingly a new alphabet and numeral code was invented. In other words, the American code has to have a supplementary code to do its work for it. Now the system of night signaling by means of a permanent hoist of lanterns similar to the Ardois has come to stay. The advantages offered of rapidity, reliability, and distinctness within the limits of distance imposed by squadron cruising, make it improbable that any device will very soon supersede it. All the principal navies of the world have adopted some such system, and the only question is as to the best apparatus, from a mechanical standpoint, for exhibiting the displays of lights needed for the different codes.

It is interesting to note, in this connection, that we are much behind other navies, in that we use five lanterns in a permanent hoist. Italy, Spain, Austria and France have adopted four lights. These, spaced in the distance formerly occupied by five or more, increase the range of visibility greatly, and with military masts and the short hoists offered by the auxiliary vessels of a fleet, such as torpedo-boats, etc., four lamps possess an enormous advantage over even five. Of course, using four lanterns implies the use either of a four-element code, or, as with the Italians, the consonants only, just as in the International code. Indeed, they have for day purposes the regular International flags, but the signal books are of course different. The principal night-signal apparatus used abroad is that on what is known as the Kaselovsky system, as improved by Lieutenant Sellner of the Austrian Navy. One of these four-lamp Sellner devices is now mounted on board the Chicago for trial as compared with the Ardois. It has, unfortunately, only twenty-seven sectors marked, and uses only the consonants. It is the type in service in the Italian Navy, and costs delivered in this country about $700. The Ardois with five lamps and sixty-four sectors is invoiced at about $1180. In point of workmanship it looks as if the Ardois were much superior, but there are excellent points in each that might well be embodied in an apparatus of home manufacture. The proposition is simply how to best and most economically mount four double (red and white) lanterns in a permanent hoist, and make certain displays of lights by means of keys. The Ardois lantern is far from satisfactory. American ingenuity can be trusted to solve the problem. An apparatus designed by Ensign F. J. Haeseler, U. S. Navy, possesses great merit, but the

field is an open one. If the Navy Department will settle the vexed question of the numerous codes we would soon have smooth sailing. There is enough data in the office of Naval Intelligence and available in the Squadron of Evolution to warrant an official inquiry and settlement, by a board of officers or otherwise, of all the points at issue. The revision of the general signal book need in no way interfere with this, although it is certainly an open question as between the use of flags similar to the International and those in the present numeral day flag code. It is generally admitted that the present method calls for too many flags in a hoist. The principal argument against any change is the great expense of devising and printing new signal books. There is, however, a further reason for going slowly in the matter. There is a growing feeling that some device like collapsing shapes will eventually supersede flags for day signals, in which case a numeral code would seem to be necessary. It will, however, be observed that this question does not enter into the one under consideration, that of night signals, for a four-element code admits of both the International (consonants) and the numeral code.

The Germans use a three-element code and a hoist of three lights. The English Admiralty in June last ordered a three-lantern Sellner apparatus for experiment. Three lanterns restricts the usefulness of the system to numeral codes only, whereas four admits of both an alphabetical and numeral code, as will be shown.

Experience in foreign services has led to the universal condemnation of the green light for general signal purposes (that is, a green transmitted light as distinguished from a chemical one, as in the Very system). Indeed, it is even so well recognized that a white light is visible in thick weather farther than a red one, that in the latest Sellner apparatus four white lights only are used. What *was* the red light in a display is now a pulsating white one, readily distinguishable from the steady white light. The pulsations are given by taking the current from a specially arranged commutator, and it is claimed that a pulsating light is visible very much farther in thick weather than even a steady white one. Dynamos and apparatus are furnished cruising torpedo-boats in some foreign services, with the fixed hoist of four lanterns. In fact, the whole question seems to have passed the experimental stage in which we find ourselves. By a simple device, in the later types of the Sellner apparatus the signal made is automatically recorded on a slip of paper, so as to check errors and preserve a record.

We have now for night signaling, both in the North and South Atlantic Squadrons, 1st, the Ardois alphabet and numeral code; 2d, the American Morse alphabet and numeral code, transmitted in one of three ways, viz., by three lights and a hand keyboard, by a torch wig-wag, or by fog whistle; 3d, two Very codes, one of three elements with brackets (the original), and a very successful and desirable experimental code of four elements. As the Coston signals have not as yet been officially suppressed, it might not be unfair to include this system and code in the list, as well possibly as the hoists of oil lamps in the general signal book. This is a somewhat chaotic condition of affairs, but the solution is absolute simplicity itself.

1st. Abolish the Coston, the oil lamps, and the original Very three-element code.

The Coston lights are from time to time sent out into service to be further experimented with. The system is a back number and should be given its quietus officially. The Very signals, as a system, are the best long-distance nautical night signals in the world, but the original code introduced the bracket in order to get a three-element code with two colors. If, however, one ball fails, as is too often the case, it is necessary to repeat the whole signal. This is not only exasperating, but is a grave defect. With the four-element code, failures do not interfere, as two minutes delay are allowed between elements. The four-element code should unquestionably be adopted in place of the original, and a further change made of using white in place of green. There is no fault to be found with the chemical green light, but as the night signal colors are now red and white, uniformity calls for the change. There is another reason which will appear later on.

2d. Retire the American Morse code, excepting for expert signalmen to use in communicating with Army stations.

3d. Drop the present Ardois code as unnecessary.

4th. Adopt the four-element Very code, for all purposes, as the numeral code.

The Very system has also come to stay, and every watch officer, watch petty officer and signalman has to know it or should be required to know it. The four-element code is as follows:

1. RRRR	2. GGGG
3. RRRG	4. GGGR
5. RRGG	6. GGRR
7. RGGG	8. GRRR
9. RGGR	0. GRRG

To use this on the Ardois or other apparatus with four lanterns, the green would show white and the red show red, but it is urged that the Very signals be changed in that respect from green to white. To use the numeral code on the fog whistle or in the ordinary wig-wag, transcribe it so that for red read *one*, and for green or white read *two*, thus:

1. 1111	2. 2222
3. 1112	4. 2221
5. 1122	6. 2211
7. 1222	8. 2111
9. 1221	0. 2112

In other words, where we now have in service four numeral codes, viz., the Morse, the Ardois, the Very three element, and the Very four element, substitute the last named for all—one for four.

5th. Adopt the Myer alphabet, dropping everything but the letters.

The service is a unit on a return to the Myer code. It was used through the war and for eighteen years subsequent. It is a four-element alphabet, and requires only four lanterns in a permanent hoist. Its elements of *one* and *two* are more distinct to the ear on a fog whistle than a dot dash system; the eye catches them more distinctly with the night flashing or winker light, and an inexperienced operator can make *one*, *two* better on a key than he can a dot, dash. It only requires one winker light to transmit the Myer, whereas the American Morse takes three.

In other words, the five propositions here submitted mean simply, *adopt what may be called the Myer-Very code for all purposes, and practically drop everything else of the kind.*

It is amazing how much this simplifies matters. The Ardois apparatus now in service can be converted without expense to the new code by pasting the Myer-Very characters over the proper sectors, and by doing away with the lowest lantern of the five. On the Philadelphia, for instance, her new masts crowd five lanterns to the point of failure, but there is full room for four. Instead of a signal box with sixty-four sectors, we would in future need one with thirty or thirty-two, and instead of five lanterns only four. This means a great saving in cost. It is proposed, with the adoption of the Myer-Very code, that signals be read in the hoist from top downwards, instead of from bottom upwards, as in the Ardois at present. This last named can be changed in five minutes to read that way.

It will be noted that there are only thirty possible combinations of the numerals *one* and *two* limited to four elements as a maximum. On the other hand there are twenty-six letters and ten numerals to be provided for in the Myer-Very, or thirty-six in all. It happens that the Very duplicates in its numerals seven of the Myer consonants, *z*, *f*, *j*, *g*, *v*, *m* and *b*; moreover, there is a still more fortunate circumstance in that the character 2212 occurs in neither. This is vital, as it comes in as the "interval" separating words and groups of numbers. The three numerals not duplicated in the Myer alphabet are 1, 3 and 8, and are available for general and code calls. The assignment is as follows:

Cornet (General call), ...	1111
Letters call, ...	1112
Numeral call, ...	2111
Interval, ...	2212

The cornet is the general call. When followed by an initial letter it calls a particular ship. The "letters" call indicates that the signals which follow are to be read as a spelled-out message. The "numeral" indicates that numerals follow. We have now in the signal book G. L. U. (geographical list use), T. D. U. (telegraphic dictionary use), S. B. U. (general signal book use), etc., and these are available for code signal calls to indicate in what book to look for the significance of the signal made. In the wig-wag, the Myer signal "numerals follow" will indicate that the signal is to be read as a numeral, or if no such signal is made, as alphabetical.

This whole scheme was, by order of the Commander-in-Chief of the Squadron of Evolution, recently submitted to a board of officers of which Captain Philip, U. S. N., was senior member, and was by that board unanimously approved. Experiments in the lines laid down are contemplated this winter. Four lanterns and thirty sectors will accomplish all that five lanterns and sixty-four sectors will, if the Myer-Very code is used. In deference, however, to the expressed fear that in restricting ourselves to thirty sectors we may be tying ourselves down for unforeseen contingencies, the writer would suggest that two or four sectors be added and a pulsating current (produced either by a commutator or an automatic make and break in these sectors) be introduced if necessary for certain unforeseen code calls or added characters. It is of very great importance that we come down to the four lanterns in a hoist instead of five.

The Myer-Very code would require the thirty sectors to be marked as follows, reading from top down:

(Note: *one* is red, and *two* white. The corresponding Ardois sectors are given to read from top down.)

		Myer-Very.		Ardois.
A	=	22	=	"Numeral"
B or 0	=	2112	=	"Gen"
C	=	121	=	2
D	=	222	=	"Error"
E	=	12	=	"Final"
F or 4	=	2221	=	"Annul"
G or 6	=	2211	=	"Understand"
H	=	122	=	H
I	=	1	=	"Interval"
J or 5	=	1122	=	T
K	=	2121	=	3
L	=	221	=	"Cornet"
M or 9	=	1221	=	I
N	=	11	=	O
O	=	21	=	1
P	=	1212	=	B
Q	=	1211	=	C
R	=	211	=	9
S	=	212	=	2
T	=	2	=	0
U	=	112	=	P
V or 7	=	1222	=	L
W	=	1121	=	Q
X	=	2122	=	4
Y	=	111	=	W
Z or 2	=	2222	=	Key No. 2
Cornet or 1	=	1111	=	"tion"
Letters or 3	=	1112	=	X
Numerals or 8	=	2111	=	Blank 45
Interval	=	2212	=	——

With regard to the Very night code there are several great improvements admissible. In the first place, the change of the green to white is very important for uniformity, and moreover there is no reason why, with the Myer-Very code, we should not be able

to use the Very signals for the alphabet for long distances instead of limiting it to the numeral code only. This can be accomplished by using the green ball for the word interval and the red and white for the elements. The importance of all this is that it enables vessels not provided with electrical apparatus to use the Myer-Very code in communicating with vessels that have. With picket launches, wooden cruisers of the old type, and torpedo-boats this is a consideration. The Very pistol should be replaced in service by double-barreled breech-loading shot-guns with short barrels.

It is never out of place to urge that signalmen be made petty officers ranking with coxswains, and that the pay be increased to $30 per month; also that quartermasters be given $35, and chief quartermasters $50.

To summarize: The service at large favors a return to the Myer code, and we must eventually adopt the Very four-element code, so why not adopt the Myer-Very code and enable us to use four lanterns instead of five in a permanent hoist? All the principal foreign services are down to four, and the Myer-Very is a step in the right direction. It leaves the question of flags *vs.* shapes open for future settlement; it brings order out of chaos; it cheapens the present apparatus; it gives us an alphabet for distant night signaling; and, above all, it offers a substitute for the American Morse code, than which nothing worse can be devised.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE STATICS OF LAUNCHING.

By Assistant Naval Constructor William J. Baxter, U.S.N.

Launching is the operation by which a ship is transferred from the building slip into the water, and is performed by causing her to rest on a carriage, *the cradle*, which is allowed to slide along lubricated inclined planes, *the ways*, that extend from the slip into the water, until she is water-borne. She may enter the water broadside on, bow on, or stern on; the latter condition only will be investigated. In discussing the statics of launching it is assumed that the ship descends along the ways so slowly that the velocity may be neglected; the effects of the actual velocity will be considered afterwards.

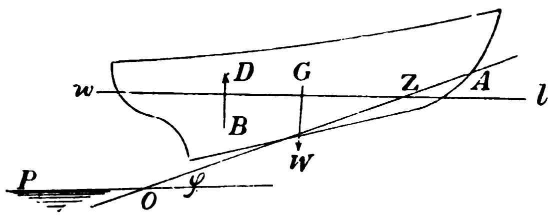


Fig. 1.

Let the ship be resting on the ways OA (Fig. 1), which are inclined at an angle ϕ, the forward end of the cradle being at A and the water-level at OP; let the water-line wl be parallel to OP. The ship will move along the ways the distance OZ before entering the water. As she continues to descend, the water-level coincides with water-lines parallel to wl, and when she has moved the distance OZ the water-level will correspond with wl. It is more convenient, however, to assume that the ship is stationary on the ways, and that the water-level has slowly risen until it is at wl; and as the inclination

of the ways is always known, with every assumed rise of water-level the corresponding descent along the ways, or the horizontal travel will be known.

The ship's weight W will act downwards through the center of gravity G at all times; but if, at any instant, the water-level is at wl there will be an upward pressure and opposite to the weight of the volume of water displaced, and this upward pressure or buoyancy D will act through the center of gravity of the displaced fluid B, the center of buoyancy. The quantity of water thus displaced is termed the ship's displacement, and is usually measured by its weight in tons; 35 cubic feet of ordinary salt water, or 36 cubic feet of fresh water, weighing one ton. As the water-level rises or falls, the volume displaced changes in shape and in quantity, causing the displacement to change in quantity and the center of buoyancy to change in position. These changes can, however, be represented graphically.

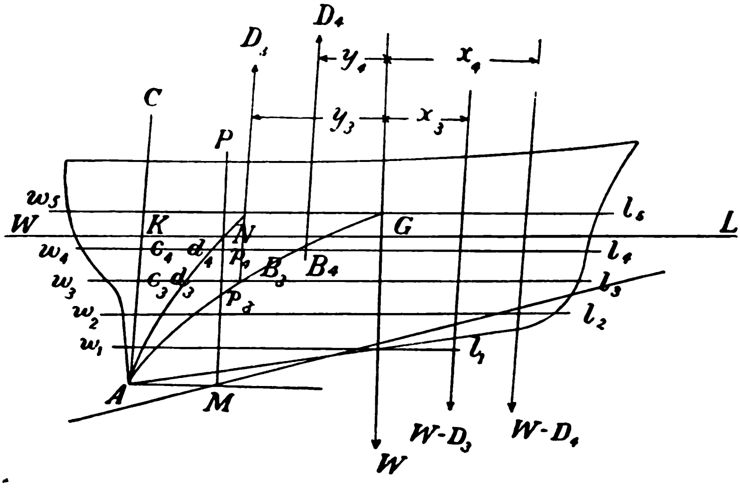


FIG. 2.

In Fig. 2, let w_1l_1, w_2l_2 .... w_5l_5 be a series of horizontal water-lines, and AC be a vertical through the foot of the stern-post; from this vertical set off along the water-lines to any convenient scale, the displacements up to each water-line; the curve drawn through the points thus plotted will be the *curve of displacement.* In like manner set off along each water-line the distance the center of buoyancy lies forward of the vertical AC; the curve drawn through these points is

called the *buoyancy curve*. It does not show the actual positions of the centers of buoyancy, but gives the intersections of verticals through these centers with the corresponding water-lines.

Having these curves drawn with the given water-line, the displacement and center of buoyancy are readily found for any other water-line, being its intersections with these curves.

The ship will float when the displacement equals the weight; then if AM represent W, to the scale of curve of displacement and the *weight line* MP be drawn parallel to AC, its intersection with the curve of displacement at N will be a point on the water-line cutting off a displacement equal to the ship's weight. This water-line WL is called the *flotation line*.

When the water-line has risen to w_3l_3 the ship's weight W acts downward through G, and her buoyancy D_3 acts upward through B_3. The resultant of these two parallel forces at a distance y_3 apart acting in opposite directions is $W—D_3$ represented by d_3p_3 acting parallel to them at a distance x_3 forward of G such that $x_3(W—D_3) = y_3D_3$.

$$\therefore \; x_3 = \frac{y_3D_3}{W - D_3}.$$

When the water-level is at any other water-line such as w_4l_4 there will be another displacement D_4, and the new line of buoyancy will pass through B_4 at a distance y_4 from G. The ship's weight remaining the same, there will be a new resultant $W—D_4$ whose line of action will be at a distance x_4 forward of G such that

$$x_4 = \frac{y_4D_4}{W - D_4}.$$

Since D_4 is greater than D_3, x_4 is greater than x_3.

As c_3d_3 represents D_3 and AM represents W, d_3p_3 will represent $W—D_3$; similarly, d_4p_4 will represent $W—D_4$.

This being true for any water-line, the equation is made general by writing it

$$x = \frac{yD}{W - D},$$

where y and x are respectively measured to the left and right of the vertical through G on the water-line passing through B; $W—D$ being represented by the distance from the curve of displacement to the weight-line MP.

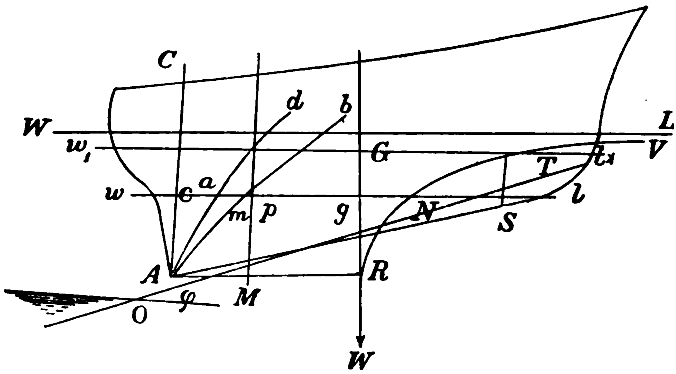


FIG. 3.

This is the equation of the *Curve of Resultants*, *R V*, Fig. 3, which passes through the intersections of the water-lines with the lines of action of the resultants. In this equation $x = 0$ when $D = 0$, so that the origin of the curve is at *R*, the intersection of the water-line passing through the lowest point of the ship, which is in most cases the foot of the stern-post, with the vertical passing through *G*, the center of gravity. Also when $D = W$, $x = \infty$, so that the flotation line is the asymptote of the curve of resultants, and the two will never meet. Knowing these properties, the curve of resultants is constructed in the following manner:

Draw the sheer plan of the ship, the bottom of the keel *A S* having the inclination of the line of keel-blocks; then the *line of ways A T* representing the top of the ground-ways in the proposed position both as regards height and inclination. Draw a number of water-lines spaced from 18 inches to two feet apart, and calculate for every water-line the displacement and distance of center of buoyancy forward of vertical through foot of stern-post *A C*, and from the values thus obtained plot the curves of displacement *Aa* and buoyancy *Ab*, and construct the weight *MP*, flotation *WL*, and gravity *GR* lines. The curve of resultants *R V* has its origin at *R*, and *WL* is its asymptote. Any intermediate point *N* corresponding to a water-line *wl* is at once found, as $ca = D$, $ap = W - D$, $mg = y$, $AM = W$.

$$\frac{Dy}{W - D} = x = gN = \frac{mg \times ca}{ap}.$$

Through the points thus obtained the curve of resultants is drawn with its origin at *R* and with *WL* for an asymptote.

For any water-line the resultant $W—D$ is equal to pa, and its line of action is the vertical passing through the intersection of the water-line with the curve of resultants at N, or the value of the resultant can be calculated, since

$$W-D=\frac{Dy}{x}=D\cdot\frac{mg}{gN},$$

so that we can at once determine the actual pressure on the ways and the line of action of this pressure. Conversely, knowing the line of the resultant, its value and the corresponding water-line can be found; thus if the line of action passes through N, wNl is the corresponding water-line, and pa the value of the resultant, which can also be calculated as before.

As the ship descends, the water-line rises, the resultant becomes smaller and its line of action moves forward. Let the forward poppet-lashing pass under the ship below S, then when the water-level has risen to w_1l_1 the line of action will pass through T. If it rises higher the line of action will pass forward of S, and if it sinks lower the line of action will pass aft of S. When aft of S the resultant meets the equal and opposite reaction of the ways, and the motion of the ship is not affected by it; but when the line of action is forward the reaction of the ways is not opposite, as it cannot move forward of S; the ship therefore pivots about its forward support at S, the stern lifting. The forward poppet-lashing, when using two lines of ways, or the forefoot, when launching on the keel, is called the *pivoting point*. While aft of this point, the pressure due to the resultant is distributed over the whole length of the cradle; but when the line of action passes through S or is forward of it, the whole pressure due to the resultant is concentrated at S. Since the value of the resultant decreases as the water-level rises, it follows that when the line of action passes through S this concentrated pressure is greatest. The ways, poppet-lashing, and ship must be strong enough to resist this *pivot pressure*, and its value should always be carefully ascertained.

As a practical example, take a ship whose launching weight is 1500 tons, having ways 18 inches broad and a cradle 200 feet long. The pressure in tons per square foot on the ways is evidently

$$\frac{1500}{200\times2\times1.5}=2.5 \text{ tons.}$$

If at the instant before pivoting, the length of cradle-support is 40 feet, and $W—D=600$ tons, the pressure per sq. ft. on the ways will be

$$\frac{600}{40\times2\times1.5}=5 \text{ tons.}$$

But at the instant after pivoting, when the line of action passes forward of the pivot, and the ship has begun to change trim, the whole resultant pressure will now be concentrated on not more than two poppets on each side, or two feet of the cradle; and if $W-D$ now equals 594 tons, the pressure per square foot will now be

$$\frac{594}{2 \times 1.5 \times 2} = 99 \text{ tons.}$$

In actual practice the pressure will be less than this, as it will be somewhat distributed over the forward pieces of the bilge-ways; but this will suffice to show how great the pressure may become, and how carefully the strength of poppet-lashings and poppets should be proportioned, to avoid all possibility of accident.

As this pivot pressure reacts on the ship, she must be strong enough to resist it, otherwise deformation or crushing may occur. Ships of ordinary form and scantling may be considered safe if the usual precautions are observed, since there have been many successful launches. But with ships of unusual types, especially those of very great tonnage or very light scantlings, a careful investigation should be made, and an ample factor of safety provided for, internal shoring being used when necessary.

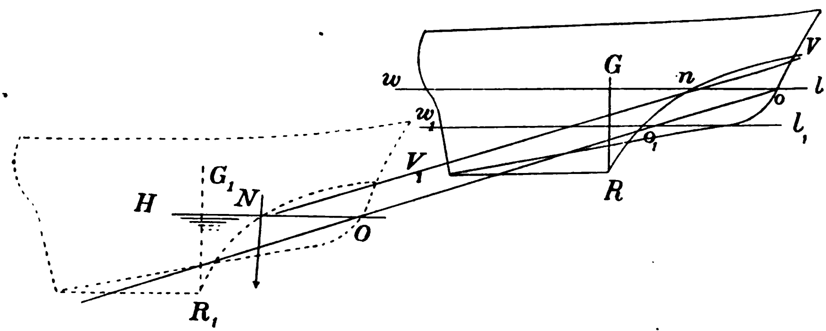


FIG. 4.

Suppose the ship to descend along the ways with inappreciable velocity and gradually enter water having a constant known level. In Fig. 4, let OH be the water-level and RV the curve of resultants, and wl be any water-line; wl will coincide with OH when the ship has moved the distance Oo. If the ship had remained stationary and the water had risen to the level wl, the line of action of the resultant would pass through n, the intersection of the curve with the water-line, at a distance on from the line of ways; when the ship has

descended the ways and occupies the position shown in dotted lines, the resultant pressure acts through N, ON being equal to *on*. The line of action of the resultant pressure will therefore pass at a distance from O, equal to the distance from the intersection of the curve of resultants with the water-line, to the intersection of this water-line with the line of ways. The intersection of the normal or average water-level with the line of ways, projected at O, is called the *shore line*.

For the water-line w_1l_1 which intersects the curve at the same point where the latter meets the line of ways, the line of action passes through the shore-line at O; and for any water-line below w_1l_1 the resultant will pass inside the shore line. It therefore follows that, as the ship descends along the ways and enters the water, the resultant downward pressure acts inside of the shore-line as long as the water-level is at a water-line whose intersection with the curve of resultants is below the line of ways, and the resultant acts outside the shore-line when this intersection is above the line of ways.

The actual position of the line of application of the resultant downward pressure during the ship's descent along the ways, when any given water-line coincides with the water-level, is found by drawing the *distance line Nn* parallel to the line of ways through the intersection of the water-line and the curve at n; ON is evidently equal to *on*, and N is therefore the point required.

This resultant pressure must meet an equal and an opposing force in order that the ship may remain in equilibrium. This opposing force is the reaction of the ways; they must evidently be long enough to produce this reaction for all positions of the ship between the original one of rest and the final one of flotation.

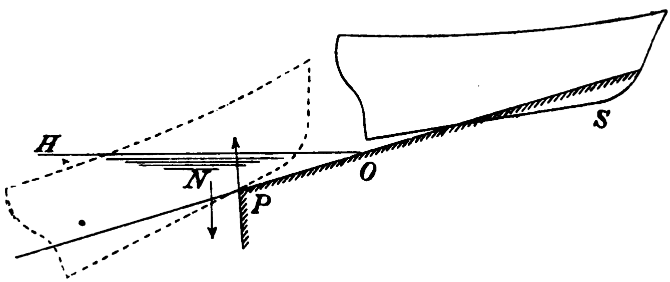


FIG. 5.

In her descent along the ways and before pivoting begins, let the ship occupy the position shown in full lines in Fig. 5, the downward

resultant pressure acting through N, OH being the water-level, S being the pivoting point, and P the outer end of the ways. There being no equal and opposing force, the resultant causes the ship's stern to descend, taking the position shown in dotted lines. As she continues to move onward she scrapes against the end of the ways, until the displacement of the after-body increases so that she begins to raise her stern, and finally her fore-body strikes on the ways again. This *stumbling* occurs often; it is dangerous and frequently results in serious damage to the ship; in shallow water the stern may strike the bottom and the launch be a vexatious and costly failure.

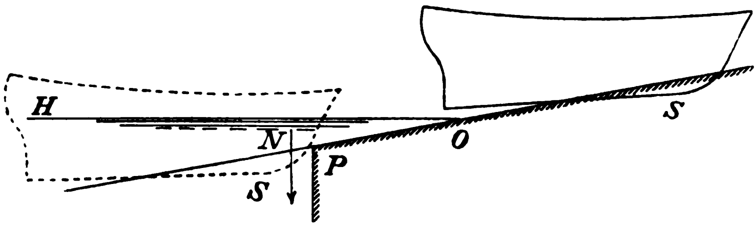


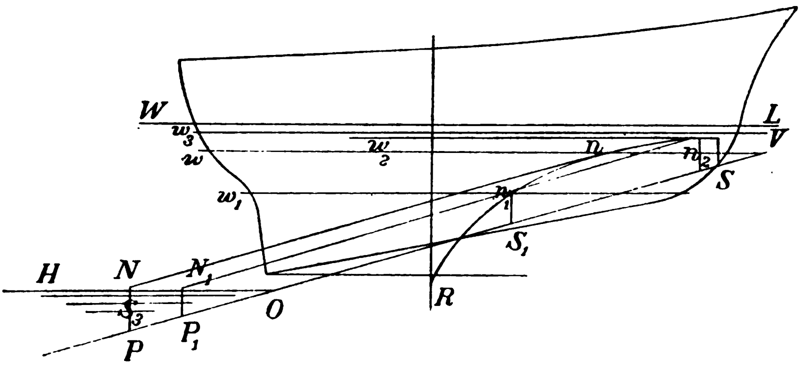
FIG. 6.

With a ship whose pivoting point S, Fig. 6, is some distance aft of the forefoot another danger may be feared if the ways are so short that the resultant passing through N acts beyond P before the ship has floated. The ship then takes the position shown by the dotted lines, the forefoot falls, striking or scraping the foot of the ways. Although dangerous, this *tripping* seldom occurs.

These phenomena, although they are modified by the effects of the ship's velocity, show the absolute necessity of having the ways of such ample length that the line of action of the resultant downward pressure shall always be inside the end of the ways, and that the pivot shall always be supported until the ship floats. When the curve of resultants is below the line of ways, it has been shown that the line of action of the resultant lies inside the shore-line and there is no danger when the ways extend into the water; but when the curve is above the line of ways the resultant moves outside the shore-line, and stumbling or tripping will occur if sufficient length be not provided of *underwater* ways, the length of ways extending from the normal shore-line measured along the line of the water-level.

Let RV be a curve of resultants in Fig. 7, OH the water-level, PS the line of ways and S the pivoting point. For any water-line

such as w_1l_1, the resultant acts through N_1; as the ship descends the resultant recedes from the shore-line until a water-line wl is reached, such that the corresponding distance-line is tangent to the curve. As the ship continues to descend the resultant now advances towards the shore-line, passing a water-line such as w_2l_2 whose distance-line corresponds with that of w_1l_1 until water-line w_3l_3 is reached and the ship begins to pivot, the resultant then acting inside of N, and it continues to advance towards the shore-line until the ship floats. If the underwater ways extend as far as P, the resultant downward pressure meets the equal and opposite reaction of the ways and the ship is always in equilibrium from start to flotation. But if the underwater ways extend only to P_1 the ship would stumble as soon as water-line w_1l_1 was passed, and would strike the ways again when wl was reached. Tripping, however, would never occur.



FIGS. 7 AND 8.

Let the pivoting point be at S_1, Fig. 7; the resultant recedes from the shore-line until wl is reached and then returns towards it. Pivoting begins when water-line w_1l_1 is reached, and if the underwater ways extend only to P_1 the ship will begin to trip as soon as she descends deeper into the water and will so continue until flotation, as the resultant rapidly moves forward and the pivoting point is unsupported thereafter. If the underwater ways did not extend to P_1, stumbling would first occur and then tripping.

In general, when the distance-line corresponding to a given length of ways is above a tangent to the curve of resultants of a given ship, neither stumbling nor tripping will occur, and the ship will be well supported from start to flotation; but when the distance-line intersects the curve, stumbling occurs when the pivoting point

is forward of the second intersection; tripping occurs when the pivoting point is at the first intersection; stumbling and tripping both occur when the pivoting point is forward of the first intersection, but between it and the second.

To prevent stumbling or tripping and to have the ship well supported from start to finish, the length of underwater ways must not be less than that given by the distance-line tangent to the curve of resultants.

The depth of water above the end of the underwater ways is known as:

Depth of water on end of ways = length under waterways $\times$ tangent of angle of inclination of ways.

Or, depth of water on end of ways = length of under waterways $\times$ descent per foot $\times \frac{1}{12}$.

Thus with underwater ways extending 48 feet beyond the shoreline and having an inclination of $\frac{3}{4}$ inch per foot,

$$\text{depth of water} = \frac{48 \times \frac{3}{4}}{12} = 3 \text{ feet.}$$

The curve of resultants can be accurately drawn, and the pivot pressure and length of ways required can be accurately determined when the following are accurately known:

1. The ship's displacement curve.
2. The ship's buoyancy curve.
3. The angle of inclination of the ways.
4. The position of the ship on the ways.
5. The position of the pivot.
6. The weight of the ship.
7. The position of the center of gravity.
8. The water-level at the moment of launching.

The first and second can at once be determined from the ship's lines and the known inclination of the keel-blocks; the third will be decided by the depth and extent of water available and other practical considerations; the fourth is known; and the fifth decided by the ship's form; all being accurately known months before the ship is launched.

But with the remaining three there is more or less uncertainty at the time the launching calculations are made. The ship's weight is only known approximately, even where an accurate record is kept of all the weights placed on board, as the amount added between the time of the calculation and the time of launching cannot usually

be accurately foreseen, since circumstances frequently arise necessitating the launch being advanced or postponed from the time originally set. Still less is it possible to foresee the exact position of the ship's center of gravity.

Nor can the water-level at the moment of launching be accurately known, especially in tidal waters. Though the height and time of mean high water are known, during the time lost by unforeseen delays the water-level will change; and in all waters, freshets and strong winds may change the level.

The variation of these three conditions modifies the curve of resultants, since it is plotted from the equation,

$$x = \frac{Dy}{W-D},$$

in which W varies with the weight and y with the position of the center of gravity. The pivot pressure and the length of ways outside the shore-line vary with the curve; and the total length of ways required will vary with the water-level although the curve remain unchanged, as the length of the underwater ways must remain constant with a given curve. All probable variations of these three conditions should therefore be considered in making the launching calculations.

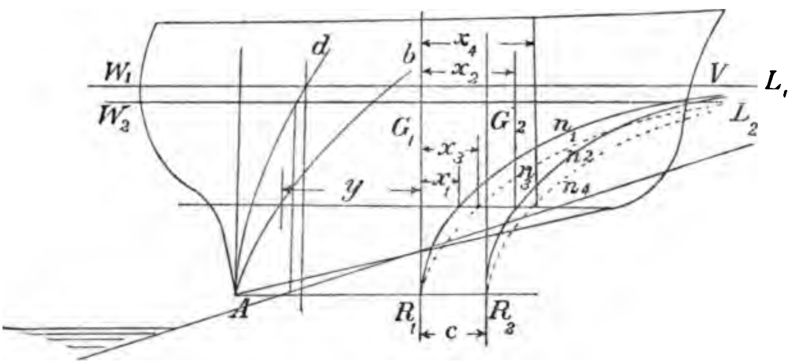


FIG. 9.

From knowledge of the design and type of ship, the probable receipt of materials and rate of progress of the work, W_1 and W_2, the respective maximum and minimum values of the ship's weight, may be assumed. Similarly assume that a and b are the respective distances abaft the midship section, of the ship's center of gravity,

giving them negative values when the center of gravity is forward. The curve of displacement *Ad* and the buoyancy *Ab*, Fig. 9, remain unchanged, but W_1L_1 and W_2L_2 will be the two flotation-lines corresponding to W_1 and W_2 respectively. Let G_1 and G_2 be the two limiting positions of the center of gravity at a distance c apart, and G_1R_1, G_2R_2 the two verticals, and suppose each weight to be concentrated first at G_1 and then at G_2.

With the weight W_1 and the center of gravity at G_1 the origin of the curve is at R_1, and W_1L_1 is the asymptote, and any point on the curve corresponding to a given water-line is found by the equation,

$$x_1 = \frac{Dy}{W_1 - D}, \qquad (1)$$

giving the curve $R_1n_1V_1$; W_1L_1 being the asymptote.

When the same weight W_1 has its center of gravity at G_2 the equation becomes

$$x_2 = \frac{D(y+c)}{W_1 - D}, \qquad (2)$$

giving the curve $R_2n_2V_2$; W_1L_1 being again the asymptote.

With the weight W_2 having its center of gravity at G_1, the equation becomes

$$x_3 = \frac{Dy}{W_2 - D}, \qquad (3)$$

giving the curve $R_1n_3V_3$; with W_2L_2 for an asymptote.

But when this weight W_2 has its center of gravity at G_2 the equation becomes

$$x_4 = \frac{D(y+c)}{W_2 - D}, \qquad (4)$$

giving the curve $R_2n_4V_4$; also having W_2L_2 for its asymptote.

The four curves of resultants given by these four equations give all the necessary information required to pre-arrange all the details of the launch,

$$x_1 = \frac{Dy}{W_1 - D}, \qquad (1)$$

$$x_3 = \frac{Dy}{W_2 - D}. \qquad (3)$$

Comparing the curves of equations (1) and (3), it is seen in Fig. 10 that D and y are the same in each; but as W_1 is greater than W_2, x_1 is always less than x_3, showing that for any water-line the ordinate

of (1) measured from the vertical G_1R_1 is less than the ordinate of (3) on the same water-line. As this is true for any water-line, curve (1) is always nearer the vertical through G_1 than curve (3), and the curves never intersect. Also as o_1n_1 is always greater than o_2n_2 and n_1p_1 greater than n_2p_2 for any water-line, the ordinate of (1) measured from the line of ways is greater than the ordinate of (3) measured from this line. This being true of all water-lines, the tangent distance line to curve (1) will be at a greater distance from the line of ways than the tangent to curve (3). But as the length of underwater ways increases with the horizontal distance of the tangent distance line from the line of ways, the length of ways required by curve (1) is greater than that required by curve (3).

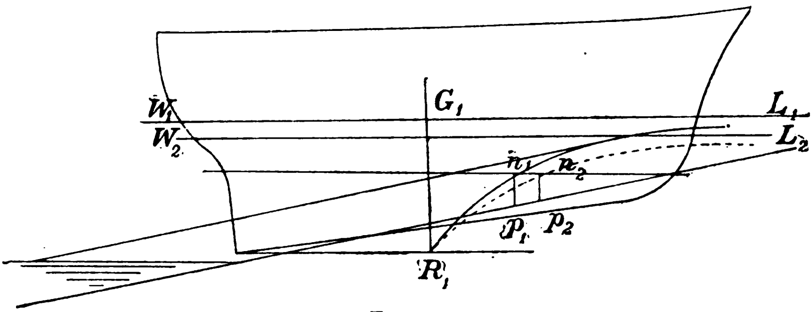


FIG. 10.

Comparing the curves of equations (2) and (4),

$$x_2 = \frac{D(y+c)}{W_1 - D}, \qquad (2)$$

$$x_4 = \frac{D(y+c)}{W_2 - D}, \qquad (4)$$

D and $(y+c)$ are the same in each, but as W_1 is greater than W_2, x_2 is always less than x_4. Curve (2) will therefore always be above curve (4) and will require a greater length of ways.

Hence, for any given position of the ship's center of gravity, the length of underwater ways required will increase when the ship's weight is increased.

Comparing the curves of equations (1) and (2),

$$x_1 = \frac{Dy}{W_1 - D}, \qquad (1)$$

$$x_2 = \frac{D(y+c)}{W_1 - D}, \qquad (2)$$

D and W_1 are the same in each, but as $(y + c)$ is greater than y, x_2 is always greater than x_1. Curve (1) will therefore always be above curve (2) and will require longer ways. For similar reasons, longer ways will be needed for curve (3) than for curve (4).

Hence, for any given weight of ship, the length of underwater ways required will increase when the ship's center of gravity is moved aft.

Comparing the curves of equations (2) and (3),

$$x_2 = \frac{D(y + c)}{W_1 - D}, \tag{2}$$

$$x_3 = \frac{Dy}{W_2 - D}. \tag{3}$$

The asymptote W_1L_1 of (2) is above the asymptote W_2L_2 of (3); and as the origin of (2) is forward of that of (3), the two curves intersect. The point of intersection cannot be determined directly from the equations, and its relative position varies with different ships; the same is true of the relative convexity of the two curves. In most ships, however, the tangent distance line of (3) is above that of (2). A less weight of ship with its center of gravity farther aft usually requires a greater length of underwater ways than a greater weight whose center of gravity is farther forward.

Comparing the curves of equations (1) and (4),

$$x_1 = \frac{Dy}{W_1 - D}, \tag{1}$$

$$x_4 = \frac{D(y + c)}{W_2 - D}. \tag{4}$$

The asymptote W_1L_1 of (1) is above the asymptote W_2L_2 of (4); but as the origin of (1) is aft of that of (2), and $W_1 - D$ is always greater than $W_2 - D$, the curves never intersect and (1) is always above (3). A greater weight of ship with its center of gravity farther aft always requires a greater length of ways.

The water-level has been supposed constant, but as it may change by the influence of tides, seasons, freshets or droughts, the effects of this change must be considered. In Fig. 11, let OH be the usual water-level, O being the shore-line, we have seen that the length of underwater ways required is $ON = on$, the distance from the point of tangency n of a tangent distance line to the line of ways measured on the water-line wl passing through this point. If the water-line be

at O_1N_1, the outer end of the ways must be below N_1 where $O_1N_1 = on$; or if the level be at O_2N_2, the outer end of the ways must be below N_2 where $O_2N_2 = on$. So that if the water-level falls, the *total* length of ways is increased the distance $N_1K_1 = \dfrac{O_1K}{\tan\varphi}$, and if the level rises, the length is decreased the distance $O_1K_1 = \dfrac{O_1K}{\tan\varphi}$. Hence, as the water-level falls or rises above the normal level, the total length of ways or the length of ways beyond the normal shore-line is increased or diminished a distance equal to the amount of this fall or rise divided by the tangent of the angle of inclination of the ways. It should be observed that the *length of ways underwater* is the same in each case, as nN is parallel to oO, and O_2N_2, OH, O_1N_1 are parallel to one another, so that $O_2N_2 = ON = O_1N_1$. But as the length of *underwater ways* is measured from the assumed average or normal shore-line at O, this length is variable, and consequently the total length of ways varies with the position of the actual water-level.

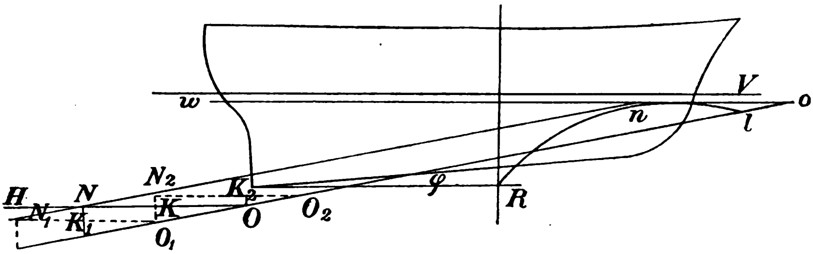


FIG. 11.

In tidal waters the shore-line assumed as normal is that of mean high tide, and the probable change of level in one hour is known. In other waters the probable level depends greatly upon the time of year. Suppose the level in either case to vary only six inches, then if the ways have an inclination of three-fourths of an inch to the foot,

$$\tan\varphi = \frac{\frac{3}{4}}{12} = \frac{1}{16}.$$

The change in length required of underwater ways is

$$\tfrac{6}{12} \times 16 = 8 \text{ feet}.$$

A slight change of level therefore requires a greatly increased change of total length of ways. If the level rises, this length is greater than necessary; but if it falls, the length is less than is necessary and

stumbling or tripping may occur. To ensure safety, therefore, the length of underwater ways should always be increased a distance equal to

$$\frac{\text{probable fall of water-level below that assumed}}{\text{tangent of the angle of inclination of ways}}$$

as a factor of safety. In tidal waters this probable fall should be that which would occur during the first hour after high water.

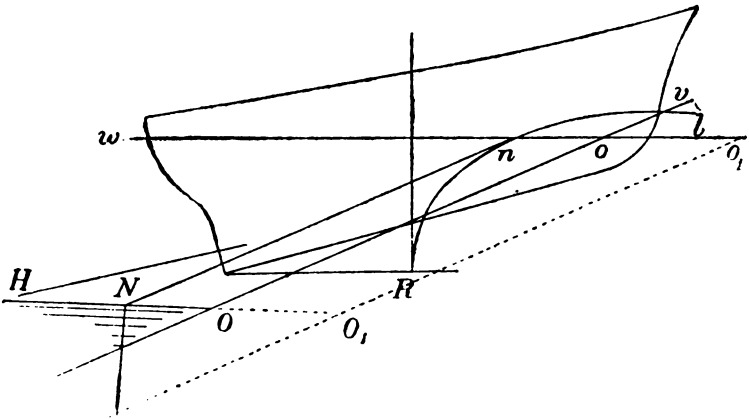


FIG. 12.

The distance of the line of ways above or below any given point on the ship, such as the foot of the sternpost, is determined by practical considerations. In Fig. 12, let the water-level be at OH, the line of ways assumed for calculation at Oo, with the shore-line at O, and let o_1O_1 be any other possible position of the line of ways. If Nn be the tangent distance line, the end of ways is determined by the vertical through N, and its position depends only on the curve and water-level.

The length of underwater ways is therefore entirely independent of the position of the ways, which may be adjusted as is found to be most advantageous.

Cost, convenience, and obstruction of the water-front must often be considered in determining the most advantageous length of underwater ways; and when possible, ways already constructed should be used. It has been shown that the length of underwater ways necessary to ensure safe launching varies with the ship's weight, the position of her center of gravity and the change of water-level.

With any given limit of length of ways, the first and second of these varying conditions should be so controlled that there will be perfect security even though the water be at its lowest probable level. The applications of the four curves of resultants can be arranged graphically so as to readily supply this information.

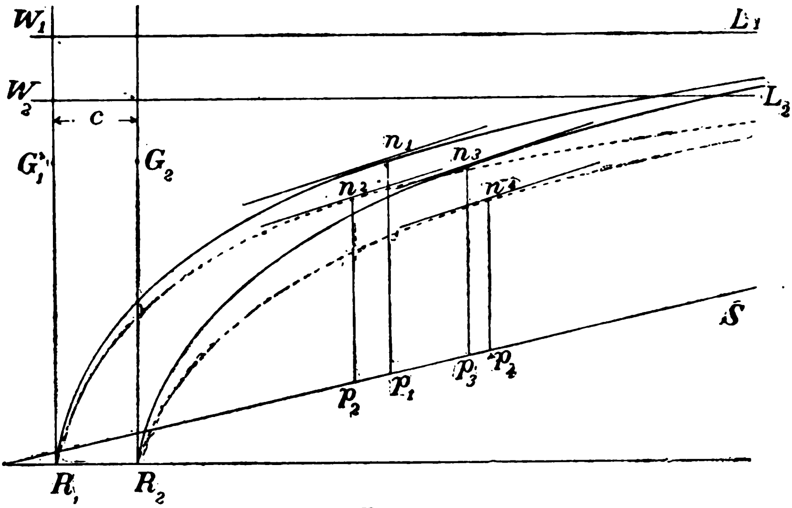


FIG. 13.

In Fig. 13, let G_1 and G_2 be the two centers of gravity at a distance c apart, then with the two assumed weights of the ship we shall have the four curves, portions of which are shown. Drawing tangent distance lines to these curves, the vertical distances between the points of tangency and the line of ways, n_1p_1, n_2p_2, n_3p_3, and n_4p_4 will represent the depths of water necessary over the end of the ways: the length of underwater ways being the depth divided by the tangent of the angle of inclination of the ways. In Fig. 14, let AB represent 8 feet, the distance c between G_1 and G_2, the two probable positions of the center of gravity, and make AN_1 equal to the length of underwater ways required by the curve R_1n_1, and to the same scale, make AN_2, BN_3, BN_4 equal to the lengths required by the corresponding curves. With ships of the usual form as commonly constructed, and with the usual launching weights, the length of underwater ways required will decrease at a nearly uniform rate as the center of gravity moves forward the distance probable in practice; hence the decrease in length of ways for any intermediate position as at E, 4

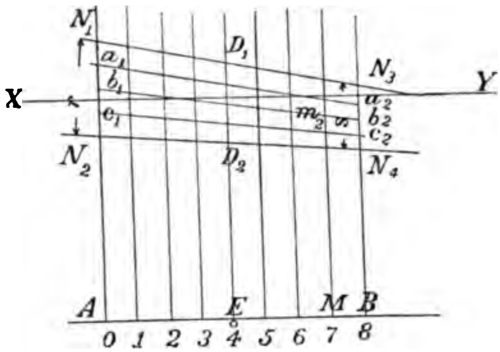


FIG. 14.

feet forward of G_1 when the ship's weight is W_1, is represented by the distance ED_1; similarly, when her weight is W_2 the length is represented by ED_2. Also, with ships of the usual form, as commonly constructed, the length of underwater ways increases at an approximately uniform rate, as the ship's weight increases, when this increase does not exceed one-tenth of the total weight; and if $W_1 - W_2 = w$ be represented by $N_1N_2 = r$ equal subdivisions, $\frac{w}{r}$ will represent the increased lengths required for these equal increasing weights. Thus if $W_1 - W_2$ equal 100 tons, and N_1N_2 be divided into four equal parts, Ab_1 will represent the length required for a weight of $W_2 + 50$ tons, when the center of gravity is at G_1. Similarly, when this center is at G_2 the length required for $W_2 + 50$ tons is represented by Bb_2. If the corresponding points of division are joined by the *meta lines* $a_1a_2 \ldots c_1c_2$ both variations are represented. Thus a point m_2 on the line b_1b_2 gives a length m_2M, corresponding to a weight $W_2 + 50$ tons with its center of gravity at a distance 7 feet forward of G_1.

To the same scale of lengths, and parallel to AB draw XY representing the maximum length of underwater ways permissible beyond the lowest probable shore-line. This line intersects some or all of the meta lines, and shows the variations of weight and center of gravity which can be safely allowed with the given length of ways.

These variations can be represented by a *distance curve RS* in Fig. 15, having the distances the center of gravity moves forward for abscissae, and for ordinates the increase of weight, to convenient scales. It is quickly plotted, as R and S are given by the intersec-

tion of XY with AN_1 and BN_3, and the other points by the intersections of XY with the respective meta lines. It is usually more convenient to make the scale of increased displacement of the distance curve some multiple of that used for the meta lines, but using the same scale of abscissae and combining them in the *distance diagram*, Fig. 16. The distance curve shows more clearly the safe variations of launching weight and position of center of gravity.

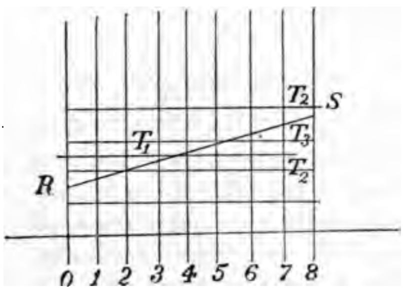


FIG. 15.

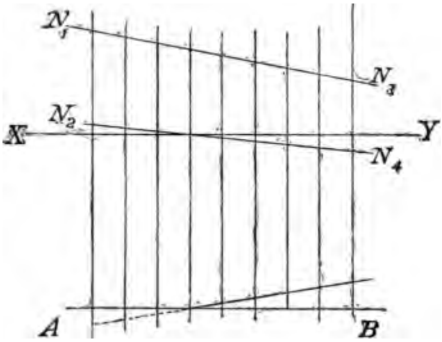


FIG. 16.

It will also indicate the necessary alterations which may be made just before the launch to ensure safety. Thus let $W_2 = 900$ tons; the day before the launch the ship's weight is found to be 960 tons, a rough calculation showing the center of gravity is 2 feet forward of G_1. This gives the spot T_1 above the curve showing that the ways are too short; the launch is unsafe. If the center of gravity can be moved forward 5 feet to T_2 there will be a safe launch. To do this by moving weights already on board would be impracticable, but when the center is at T_2, 50 more tons may be added with safety. To move the center of gravity forward 5 feet, these 50 tons must be placed at a distance S forward of G_1, and taking moments about G_1,

$$S = \frac{(960+50)\times 7}{50} = 141.4 \text{ feet.}$$

Thus by adding 50 tons of ballast 141.4 feet forward of G_1, the ship can be launched with safety.

It should be borne in mind, however, that the center of gravity must not be changed by adding a greater weight of ballast than 50 tons at a less distance from G_1, as in that case the increased weight would be greater than could be safely launched with the given ways,

as they would be too short. Thus if 60 tons were placed 118 feet forward of G_1, the center of gravity would still be 7 feet forward of G_1, but the total weight would now be 1020 tons and the corresponding spot would now be at T_3, above the curve, and the launch would be unsafe; but ballast less than 50 tons can be added at a greater distance than 141.4 such that the center of gravity is still 7 feet forward of G_1, as the corresponding spot will then be below the curve.

There are three types of distance curves: First, where XY does not intersect the limiting meta lines N_1N_3 and N_2N_4, as in Fig. 14. The distance curve is continuous and similar to that of Fig. 15, and the launch will be safe for all weights less than $W_2 + x^{\frac{w}{n}}$ at the after assumed position of the center of gravity; and for the forward position, will be safe for all weights less than $W_2 + y^{\frac{\ }{n}}$.

Second, when XY intersects the lower water-line, as in Fig. 16, the distance curve cannot be accurately plotted abaft the intersection, as shown by the dotted line, and the launch will not be safe for a weight of W_2 unless the center of gravity is forward of the intersection. In this case great care must be taken.

Third, when XY intersects the upper meta line, as in Fig. 17, the distance curve cannot be accurately plotted forward of the intersection, as shown by the dotted line, and the launch will be safe for all weights greater than $W_2 + x^{\frac{w}{n}}$, a very unsafe launch.

Fourth, when XY intersects both limiting meta lines, as in Fig. 18, in this case the launch may be dangerous or very safe, depending on the position of the center of gravity, and great care must be taken.

The length necessary for the underwater ways may be reduced in another manner. In Fig. 19, let the curves of displacement and buoyancy give the curve of resultants RV_1 by the equation

$$x_1 = \frac{D_1 y_1}{W - D_1}.$$

Suppose the volume of the after-body of the ship to be increased without increasing her weight; the curves of displacement and buoyancy will then be represented by the dotted lines giving the dotted curve of resultants RV_2 from the equation,

$$x_2 = \frac{D_2 y_2}{W - D_2}.$$

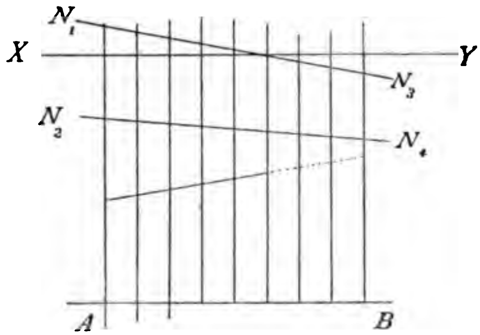


FIG. 17.

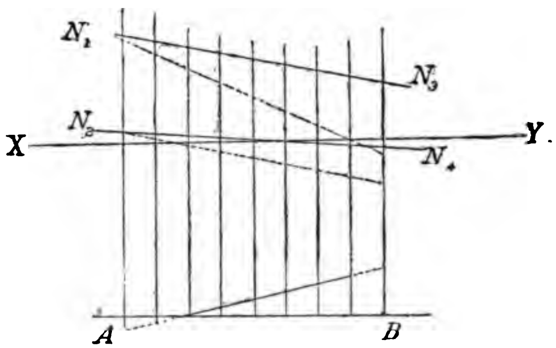


FIG. 18.

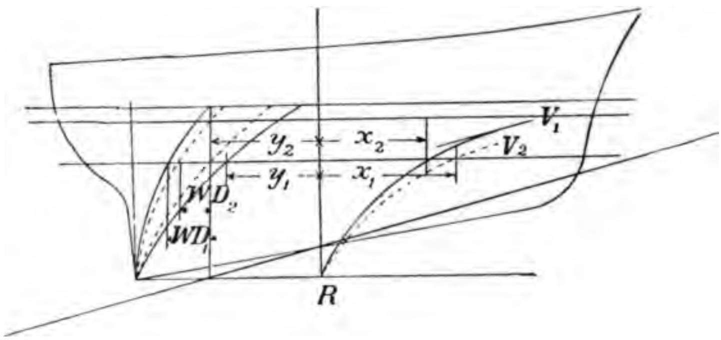


FIG. 19.

the buoyancy of the zone; so that as the sum of the upward forces is $(W - D) + D = W$, the weight and buoyancy being equal, the ship will float.

The force $W - D$ acting downward through H, being equal and opposite to the force $W - D$ acting upward through S, a couple, whose moment is $(W - D)a$, is found which would cause the vessel to rotate were it not for the moment of longitudinal stability,

$$W . GZ = W . Gm . \sin \rho,$$

acting in the contrary direction.

The ship will therefore be in equilibrium when these moments are equal.

$$W . Gm . \sin \rho = (W - D)a,$$

$$\therefore \; W - D = W . \frac{\sin \rho . Gm}{a}.$$

In practice a sufficiently accurate approximation may be made by assuming H, Fig. 20, to be on the vertical through B.

Hence with the sheer plan of the ship, the positions of G, B, and S being plotted, and the values being known of W, Gm, and the inclination of the keel-blocks, the amount of pivot pressure is found by direct calculation.

This will be especially useful when it is desired to ascertain whether a slip has sufficient strength to permit the launching of a large and heavy ship; and whether the ship is of such scantlings as will prevent deformation due to the excessive concentrated stresses during the pivoting period of the launch.

It will be observed that the pivot pressure increases as $\sin \rho$ increases; the greater the difference between the inclination of the keel-blocks and the inclination of the keel after launching, the greater is the pressure. It is therefore advisable to have this difference as small as practical considerations will permit.

A ship with any drag launched bow on will have a much greater difference than when launched stern on, the pivot pressure will therefore be greater in the former case, and for this reason ships are usually launched stern on.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH,

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NOTES ON THE LITERATURE OF EXPLOSIVES.*

By CHARLES E. MUNROE.

No. XXIII.

The Fifteenth Annual Report of H. M. Inspectors of Explosives, being for the year 1890, shows that though the rigid system of inspection and supervision of explosives factories and magazines, for which this corps is famous, has been maintained, it has not retarded the growth of this important industry, for during the past five years the number of factories in operation has increased from 108 to 123, while the number of persons employed has increased from 7484 to 9820. Notwithstanding this increase in production, the number of accidents occurring during the manufacture and use or abuse of explosives was 132, resulting in 44 killed and 85 wounded, while the average number of accidents for the past ten years was 137.8, resulting, on the average, in 41.4 killed and 102.6 wounded.

No statistics regarding production are given in these reports. This is very much to be regretted, as they would prove a most valuable criterion by which to measure the value and operation of the Explosives Act. Statistics are, however, given for importations, from which it appears that there was an extraordinary decrease in the amount of dynamite imported in 1890, it being but 371,650 pounds, as against an average yearly importation of 1,000,000 pounds for the past eight years. Part of this was accounted for by the increase in the amount of the gelatine explosives, yet the total of

*As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address Torpedo Station, Newport, R. I.*

all nitroglycerine explosives imported was less than for 1889 by over 400,000 pounds. 38,000 pounds of bellite, 9700 pounds of fulminate, and 10,950,000 detonators were also imported.

Dr. Dupre's report shows that in 1890, for the first time, the number of samples of gelatinized preparations examined exceeded those of dynamite, and points out that this increased use is due to these bodies being practically unaffected by water, and capable of being graduated in strength with greater readiness than obtains for dynamite, while in addition their plastic nature renders them more easy of use in bore-holes. These explosives are not free, however, from dangers of their own; dangers which manufacturers have not, as yet, completely overcome. The chief of these is their liability to exude. There is also a greater difficulty in insuring absolute stability under the most trying conditions of temperature and storage. Since the establishment of the manufacture of dynamite on a large scale, no authentic case of its spontaneous ignition is on record; whereas there are several such in regard to gelatinized preparations.

The consumption of dynamite is also being affected by the introduction of ammonite, bellite, roburite, securite, etc., whose greater insensitiveness to percussion and friction gives the advantage of somewhat greater safety in manufacture and use.

The different results obtained by different analysts in applying the "heat test" to blasting gelatine and its class has led to a precise description of the French chalk to be used.

For the assistance of inventors who desire to have explosives examined, a memorandum giving the necessary steps to be taken is printed in this report.

The chapter on accidents by fire or explosion, which is a characteristic and important feature of these most valuable reports, occupies some thirty-seven pages, and as usual includes a summary review of the accidents reported from abroad, as well as those occurring at home. It is noted that in the explosion of 80 tons of gunpowder at the Dupont works, October 7, 1890, a larger quantity was involved than in any previous accidental gunpowder explosion. The accidental explosion next in magnitude was that of Erith in 1864, when 57½ tons of powder exploded. The Louisiana, which was intentionally blown up before Fort Fisher in 1864, contained 200 tons of gunpowder. The author, in commenting on this, is misled by our complicated geographical nomenclature.

Extracts from this record of accidents and of that of experiments will be found later on.

Lt. Willoughby Walke, Second Artillery U. S. A., gives in *Jour. Am. Chem. Soc.* **12**, 256–274; 1890, the results of his "Determination of the Strength of Various High Explosives" by the use of the Quinan pressure gauge,* in which he employed nitroglycerine made by the Naval Torpedo Station method and carefully stored until it was thoroughly "clear," as the standard. This period of rest of several months was found necessary, as the strength of the explosive varied from day to day until it had "cleared," after which it remained constant. The results obtained were as follows:

Name of Explosive.	Diminution in Height of Cylinder in Inches.	Order of Strength.
1. Explosive gelatine made from nitroglycerine after the Vonges process	0.585	106.17
2. Hellhoffite	0.585	106.17
3. Nitroglycerine (made Nov. 19, 1889, tested Jan. 6, 1890)	0.551	100.00
4. Nobel's smokeless powder	0.509	92.38
5. Nitroglycerine (made Jan. 29, 1890, tested on same day, U. S. N. Torpedo Station process)	0.509	92.38
6. Explosive gelatine (made from nitroglycerine No. 5),	0.490	88.93
7. Gun-cotton (U. S. N. Torpedo Station, 1889)	0.458	83.12
8. Gun-cotton (Stowmarket, 1885)	0.458	83.12
9. Nitroglycerine (made according to the French process and tested on the same day)	0.451	81.85
10. Gun-cotton (made in Artillery School Laboratory),	0.448	81.31
11. Dynamite No. 1	0.448	81.31
12. Dynamite, de Trauzl	0.437	79.31
13. Emmensite	0.429	77.86
14. Amide powder	0.385	69.87
15. Oxonite (picric acid fused before being added)	0.383	69.51
16. Tonite	0.376	68.24
17. Bellite	0.362	65.70
18. Oxonite (picric acid not fused)	0.354	64.24
19. Rack-a-rock	0.340	61.71
20. Atlas powder	0.333	60.43
21. Ammonia dynamite	0.332	60.25
22. Volney's powder No. 1	0.322	58.44
23. " " 2	0.294	53.18
24. Melinite	0.280	50.82
25. Silver fulminate	0.277	50.27
26. Mercury fulminate	0.275	49.91
27. Mortar powder, Dupont	0.155	28.13

* Proc. Nav. Inst. 8, 663; 1882.

U. S. Letters Patent No. 455,217, June 30, 1891, have been granted Carl Lamm for an invention, the object of which is to provide an explosive less dangerous than nitroglycerine in its manufacture, transportation, and use.

He describes this explosive as being in the nature of a compound consisting of a nitrate (such as nitrate of ammonia, of potassa, of soda, or of baryta) and dinitro-benzine, or dinitro-benzol mixed in such proportions that when exploded the hydrogen of the dinitro-benzine or dinitro-benzol burns and forms water, and the carbon of the same material forms carbonic acid at the expense of the oxygen contained in the nitrate conjointly with the oxygen contained in the dinitro-benzine. He has also had in view the protection of the nitrates from the influence of moisture, and for this reason the dinitro-benzine or dinitro-benzol, which is a solid, is pulverized, as is also the solid nitrate, and both are then mixed and heated by steam in suitable molds to 212° F., which causes the dinitro-benzine or dinitro-benzol to melt between 176° and 212° F., and to completely envelope the particles of saltpeter or other nitrate used. The mass solidifies in cooling, and is molded into cartridges or bodies of any suitable shape, or it may be pulverized or granulated.

He has found the following proportions of ingredients to give the best results: dinitro-benzine, one part, and nitrate of ammonia, at least 1.9 parts; dinitro-benzine, one part, and nitrate of potassa, 0.96 part; dinitro-benzine, one part, and nitrate of baryta, 1.24 parts; dinitro-benzine, one part, and nitrate of soda, 0.81 part.

The above proportions are so selected as to yield or form carbonic oxide and water on explosion.

If the proportion of saltpeter or other nitrate be increased about three times, carbonic acid and water will be formed, which gives the best results for mining purposes.

He states the advantages of this explosive as: Impossibility of explosion from shock or blow; non-ignition by fire; possession of more power than other high explosives; non-congelation at a low temperature; pulverization without danger previous to use; safety in transportation and storage; advantageous use in coal mines in place of gunpowder, and requiring from a fourth to a fifth only of the quantity.

He claims: 1. An explosive compound composed of a nitrate salt and dinitro-benzine or dinitro-benzol substantially as and for the purpose specified; 2. an explosive compound composed of nitrate

of ammonia and dinitro-benzine or dinitro-benzol, substantially as described.

In his improvements relating to the manufacture of nitrocellulôse or pyroxyline, English Patent 20,978, Dec. 23, 1890, G. M. Mowbray uses, as raw material, cotton rags, cotton lint from cotton-seed hulls, and other materials, instead of fine pure unsized cotton tissue paper, and first steeps it in a bath of a salt, preferably a nitrate, and then passes it between rollers and slowly dries it. The salt crystallizes in the cells of the fiber, and this action opens up the cells so that when the material is subsequently immersed in the acid bath, nitration takes place more rapidly and is effected at less cost than by the present process. It is pointed out that, although a nitrate is preferred, "any salt crystallized, or even water crystallized by freezing, in the cells of the fibrous cellulose, facilitates nitration by rendering the inner walls of the cellular tissue more readily accessible to the acids of the immersion bath."—*Jour. Soc. Chem. Ind.* **10**, 271; 1891.

U. S. Letters Patent No. 454,281, June 16, 1891, have been granted Hiram S. Maxim for "Method of Making Gun-Cotton." He claims to render available, by this method, all the valuable properties of the acids, and to be able to use such acids until they have become entirely spent, or until they have parted with nearly all their constituents that go to effect the nitration of the cotton. The method involves the employment of a series of six receptacles or vats filled with a mixture of the strongest acids procurable. These vats are arranged on a table or platform, mounted so as to turn about a central pivot or shaft.

In using this apparatus a given quantity of cotton is immersed, say, in vat 1. It is then removed and freed from the excess of acid by any suitable means, such as a centrifugal separator. The acid separated from the cotton is returned to the vat from which it was taken. The cotton is then immersed in vat 2, and again freed from the absorbed acids by the separator, the table, prior to such separation, being turned so that the acid from the discharge of the separator will be delivered to vat 2, from whence it came. In the same manner the cotton is dipped in succession in each vat, and the surplus acid squeezed from it back into its appropriate tank. After successive charges of cotton have thus been treated the acid becomes weakened or spent, that in the first vat of the series to the greatest degree, and

quantity of water while turning the machine slowly. This succession of drying and washing permits a perfect cleansing to be rapidly effected by twelve or fifteen alternations. All the washings should be made with pure water as cold as possible. For wetting the fiber between the centrifugal drying operations the machine may be turned slowly and the water thrown on the mass of pyroxyline; but the water must be very pure in order not to leave any deposit in the mass.

It is claimed the invention has the following defined novel features or improvements, viz. The described improvement in the manufacture of pyroxyline, consisting in the successive steps of nitration, centrifugal extraction of spent acids, washing of the pyroxyline, and neutralization of the wash water by an alkaline or basic material for the recovery of the residue of nitric acid left in the pyroxyline by the centrifugal action.

The described improvement in the manufacture of pyroxyline, consisting in the successive steps of nitration, centrifugal extraction of acids, washing with water to remove the acid left after the centrifugal extraction, neutralization of the acid in this water, and its re-use with successive quantities of pyroxyline, and successive alternations of washing with water, and centrifugal dryings of each quantity of pyroxyline.

In his description of the "Preparation of Cotton-Waste for the Manufacture of Smokeless Powder," *Centrbl. f. Textil. Ind.* **21,** 975; 1890, A. Hertzog states that the military authorities require a cotton which, when thrown into water, sinks in two minutes; when nitrated, does not disintegrate; when treated with ether, yields only 0.9 per cent of fat; and containing only small traces of chlorine, lime, magnesia, iron, sulphuric acid, and phosphoric acid. The waste from the spinning machines and the looms is boiled with soda-lye under pressure, washed, bleached with chlorine, washed, treated with sulphuric or hydrochloric acid, washed, centrifugaled, and then dried. When the cotton is very greasy it is first boiled with lime water. The loss in these treatments varies largely; for example: Moisture, 3-15 per cent; packing, and in transit, 2-5 per cent; boiling and washing, 5-40 per cent; bleaching, 1.5-20 per cent.—*J. Soc. Chem. Ind.* **10,** 161; 1891.

U. S. Letters Patent No. 420,445, of February 4, 1890, have been granted Joseph R. France, who claims to have invented certain new

and useful Improvements in Soluble Nitrocellulose and its Process of Manufacture.

According to his statement, soluble nitrocellulose as hitherto made is not uniform in its character and qualities. His object is to secure an article that is uniform in these respects, and therefore reliable for the purposes to which it is adapted, and this by an easier and more certain process than that hitherto employed.

Heretofore it has been customary, according to one method, to first free the cotton from impurities by washing it in an alkaline solution; second, wash it in pure water; and third, dry it. It is then passed into a bath containing the mixed acids, which are kept at an even temperature of about 60°, by means of ice in hot weather and warm water in cold weather, and there allowed to remain for a length of time, according to the condition and nature of the fiber, the strength of the acids, etc., until the desired chemical changes are supposed to have taken place. When it is removed, the acid is first pressed out by repeated plunging into clear water. Some objections to this method of treatment are, that the action of the mixed acids upon the cotton fiber is slow, irregular and imperfect, and cannot be subjected to any uniform rule. Both expense and care are required to maintain the even temperature, notwithstanding which, some lots will reach the point of "nitration" much sooner than others, necessitating constant watchfulness.

His explanation of the slow, irregular and imperfect action of the acids in the above-mentioned process is, that however uniform the mixed acids may be in strength and proportions, and however carefully the manipulations may be conducted, there are variable elements found in different samples of cotton which defy prognosis and defeat any regular system of rules. The cotton fiber has for its protection a glazed surface, as it were, enameled by nature. It is tubular and cellular in structure, and contains a natural lubricating semi-fluid substance, composed of characteristic oil, or gum, or water, or other material, or a combination thereof. Both the glaze and the lubricating substance vary with the soil, the climate and other accidents of growth, as do other characteristics of the fiber. The tubes of the fiber seem to be open at one end only, when the fiber is of normal length.

Some or all of these elements play their parts in resisting or otherwise modifying the action of the acids upon the fiber. When the cotton is subjected to the action of the acids in its natural state and

length of fiber, the line of least resistance seems to be by way of the inside of the tubes constituting the fiber of the cotton, into which they are taken in part by capillary attraction, subject to change themselves as they progress, and to the increased resistance from the oil or the gum, etc., in their progress, and therefore to modified action, the result of which is slower and slower and otherwise more and more imperfect chemical change. It may also be that the power of capillary attraction is balanced in the tubes by air contained therein, after a little, sufficiently to prevent the acids from taking full effect. These objections he overcomes in the manner to be shown hereinafter.

Another method consists in making the cotton up into yarn and hanks, and treating it in that form with acids in the usual manner. It is found that the twisting of the fibers and the disposition in the yarn form, and the forming of hanks therefrom, causes a certain resistance to the penetration and to the action of the acids, with the result that parts of the fibers are not acted upon or acted upon imperfectly.

Still another method consists in taking paper expressly prepared from cotton fiber for the purpose, passing it through the acids, washing, drying, grinding, etc., as before described. In this last case the fibers are of course modified both by the chemical and also by the mechanical treatment to which they have been subjected in the preliminary preparation of the paper; but if the oil or gum or the glaze has been attacked by them, and if they, all of them, have been removed by subsequent washing, etc. (which is very difficult, if not impossible to do), the character of the cotton fiber itself seems to have been changed chemically, mechanically, and by felting, so that the cellulose product of the paper process is not uniform or otherwise always satisfactory. In all these methods temperature is found to be an important condition.

He uses the cotton fiber in its natural state, made pure and free from extraneous substances as possible, but cut, pulverized or ground in advance as fine as possible, even to a dust, by the mechanical means and to the extent set forth in an application filed by him February 5, 1884, Serial No. 119,845, and in that condition subjects it to the acids and to all the subsequent manipulations required to produce soluble nitrocellulose, to be described hereinafter. The principle of his method is that, whereas in the first-named old process the acids attack the fiber, say of half an inch or an inch in length, from one

end and the outside, in his process, when any natural cotton dust is used, each particle will have two more mouths or openings by which the acids can enter for every additional piece into which the fiber is cut, and in addition the glaze of the fiber may be broken up by the cutting, rubbing and grinding operations to which it is subjected in advance, thereby giving the acid a better opportunity for external attack as well. In his method the cotton fiber becomes a homogeneous mass of particles or dust, consisting of very small bits of the material, each one of which is attacked by the acids and by coming in contact with the same, the result being uniform in character in the time required for nitration, and also in the uniform equivalents of nitrogen taken up in producing the desired product.

The cotton dust is placed in a bath containing the mixed acids in the usual well-known proportions required to produce the article at any ordinary temperature—between 40° and 90° F.—and allowed to remain for a uniform length of time, in proportion to the strength of the acids, until the point of nitration is reached. The surplus acids may be removed by pressure or extraction, or the nitrocellulose may be left in the acids for an indefinite length of time, according to convenience, without change, or injury, as in the process now in use.

He states that: "In my process I avoid several of the operations employed in the methods previously described, and I substitute an improved base or material to be treated, having superior qualities for the purpose, which enable me to omit some of the steps required where other base material is used, as follows:

"1. I do not find that it is necessary to wash either the cotton fiber or the cotton dust in any alkaline solution. Consequently, I omit that operation entirely, and find that I produce a superior article of nitrocellulose when it is omitted, and this with certainty in each and every instance.

"2. The washing in pure water and the drying are therefore omitted also.

"3. The watching and constant attention to the temperature I also avoid.

"4. I avoid the loss of material which occurs from premature or imperfect nitrations, and the danger of spontaneous combustion.

"5. I avoid the want of uniformity in the resulting product.

"6. I avoid both capillary obstruction and much of that arising from the enamel or glaze of the fiber.

"Among the advantages resulting from the use of my cotton dust are the following:

"1. The product is always uniform both in appearance and chemically, and will remain stable for a long period.

"2. It is always evenly soluble.

"3. It is not liable to spontaneous combustion.

"4. The remaining acids are more easily and more thoroughly washed out after the point of nitration has been reached.

"5. My soluble nitrocellulose can be more cheaply produced, since waste is avoided and time is saved in washing.

"6. Less watching of the process of nitrogenizing is required.

"The fact that the cotton is in the form of dust, and in that finely comminuted form is acted on more quickly and perfectly by the acids, is important also, and has its proper effect in the washing stage above mentioned, giving more prompt and complete access to the water and egress to the acids.

"The soluble nitrocellulose made from my cotton dust is distinguishable from its cotton dust base by its explosive quality, and by a certain dull uniform massed and slightly felted appearance, showing that it has not been subjected to mechanical disturbance subsequent to its subjection to the action of the acids. In other respects it corresponds in appearance to the cotton dust from which it is made. It is distinguishable from the highly explosive or insoluble nitrocellulose by the fact that it can be dissolved in the usual preparation of ethyl, or grain alcohol and ether, as used in making collodion, or in methyl or wood alcohol of 95 per cent to 100 per cent. It is distinguishable from soluble nitrocellulose made by the old process, which has been reduced to dust subsequent to subjection to the acids, by its appearance, as above stated, showing that it has not been subjected to mechanical disturbance subsequent to its subjection by the action of the acids.

"In practicing this invention I find that taking one-pound batches of finely ground cotton, which is immersed in the mixed acids of varied proportions according to solubility required for a good soluble nitrocellulose, a proportion of eight (8) parts nitric acid 42° Beaumé and of sulphuric acid twelve (12) parts 66° Beaumé, is suitable. The cotton is stirred into the bath of mixed acids for fifteen (15) minutes, the superabundant acids are pressed out, and the cotton then washed in successive waters until entirely free from acids. Using cotton dust, I can thus nitrate effectively at an ordinary temperature—say from 50° to 100° F. I usually prefer to keep the room in which the nitration is carried on at a temperature of about 75° F., but I find no

perceptible difference in the nitrations at ordinary temperatures, as before stated, and I attribute the advantages over the old methods here indicated to the use of the cotton dust, as stated herein; but I do not desire to limit my invention either to the exact proportions of the acids or to the exact temperature above set forth, as by the use of my cotton dust I am able to vary the range both of proportions and of temperature greatly and yet accomplish the purpose of my invention in a superior manner.

"I am aware that it is not new to produce an impalpable powder from cellulose by the use of chemicals and afterwards treat the same for the production of pyroxyline or nitrocellulose, and this I do not claim."

What he does claim, as his invention, is as follows:

1. The process of making nitrocellulose, which consists in mechanically reducing cotton to a uniform and homogeneous dust-like condition, and then subjecting it to the action of a bath of nitric and sulphuric acids in about the proportions and at the temperature stated.

2. The process of making nitrocellulose, which consists of subjecting mechanically comminuted cotton in a homogeneous dust-like condition to the action of a bath of nitric and sulphuric acids in about the proportions and the temperature stated.

3. As an improved article of manufacture, soluble nitrocellulose composed of pure mechanically comminuted cotton fiber nitrated, substantially as described.

U. S. Letters Patent No. 457,002, August 4, 1891, have been granted Ebenezer Kennard Mitting, for a "Process of Making Nitro-Glycerine." In his specification, after referring to the usual manner of making nitroglycerine in the three varieties known to chemists as mononitro, dinitro, and trinitro-glycerine, and of which the trinitro is the only variety which is of practical utility as an explosive, he states that the operation is defective, owing to the fact that the last portions of the glycerine added to the acid are not converted into trinitro-glycerine, by reason of the weakening of the acid mixture by the water formed in the reaction earlier in the operation, the presence of a comparatively large excess of anhydrous or nearly anhydrous nitric acid being essential to thoroughly convert the glycerine into trinitro-glycerine. Consequently the full theoretical yield of nitro-glycerine (or a close approach thereto) is never obtained in practice,

a certain loss always resulting from such portion of the glycerine which has not been converted at all, or only converted into the mononitro variety, being dissolved in and carried away by the wash water, while another and variable proportion may have been converted into the dinitro variety, and a portion of this may remain after washing together with the bulk of the trinitro, reducing its specific gravity and explosive force. Various means have been proposed to overcome this defect and improve the yield of trinitroglycerine. It was thought that the admixture of the acid with the glycerine in thin streams, allowing the whole to presently run into a collecting tank, would overcome the difficulty; but this device did not succeed, owing to the fact that the reaction is not completed, except (as stated above) in the presence of a large excess of anhydrous nitric acid. Consequently the same conditions were brought about in the collecting tank as obtained in the case of running the whole of the acid first into the tank and then adding the glycerine slowly, viz. that the last portions of the glycerine were not fully converted. Again, it was proposed to first treat the glycerine with only a portion of the usual amount of acid to remove the spent acid and then treat with the remainder, and for the better prosecution of this process to vary the quality of the acids used for the first and last treatment, and even to make the process a continuous one. So far as he was aware, this mode has not proved successful in practice, because it fell short of providing the necessary excess of nitric acid at the close of the operation. It has also been proposed to use double and treble the usual quantity of acid; but this device has not been successful, and on the other hand the cost has been so largely increased as to be almost prohibitive.

The object of his invention is to overcome the difficulty above set forth and to convert the whole or practically the whole of the glycerine into trinitro-glycerine, and thus produce a yield more nearly approaching the theoretical quantity, and to effect this improvement without the use of additional acid beyond the usual quantity now employed.

In carrying his invention into effect, he first proceeds with the nitration of the glycerine in the usual manner, viz. by charging the nitrating vessel with the mixed acid, say about 8 parts, by weight, for every 1 part of glycerine to be nitrated, and at the close of the operation and after separation has taken place he draws off the spent acid in the usual manner. In the meantime he prepares another lot

of mixed acid for the next succeeding lot of glycerine; but before using it for such next lot he runs into and mixes with it the nitroglycerine produced from the first operation. The effect of this is to expose the nitroglycerine produced in the first operation to the full effect of the large charge of anhydrous nitric acid intended for the second operation, and thus convert any of the lower nitroglycerine into the trinitro variety. After allowing the mixture to settle he draws off the supernatant trinitro-glycerine to the washing tanks and proceeds with the nitration of the second lot of glycerine with the acid (originally intended for it) in the usual way, and the nitroglycerine thus produced is in its turn fed into and mixed with the lot of acid for the next succeeding nitration, and so on continuously, using always the fresh acid first upon the last preceding lot of glycerine which has been nitrated, and then to nitrate a fresh lot of glycerine, as described. The fresh acid after acting upon the product of a previous nitration contains a little water, such water being that produced in the reaction, as will be readily understood. This, however, is of comparatively small amount and does not seriously affect the succeeding nitration, especially as same is in reality completed by exposure to the next lot of fresh acid.

The foregoing operations he performs in one nitrating vessel by proceeding as follows: he first nitrates a charge of glycerine in said nitrating vessel and allows the mixture of nitroglycerine and spent acid to settle and separate, and then draws off the spent acid only, leaving the nitroglycerine in the nitrating vessel. He next runs into that nitroglycerine the charge of mixed acid intended for the next nitration (this operation is performed quickly and with perfect safety under the usual precautions), and having mixed the liquids he allows them to settle and separate, and next draws off the supernatant nitroglycerine (to be washed and otherwise dealt with) by a faucet fixed at a proper level, or equivalent means, leaving the acid in the nitrating vessel ready to receive a charge of glycerine, which he now runs into it. He next allows the mixture to settle and separate, draws off the spent acid, and proceeds to run into the nitroglycerine the charge of fresh acid, as before, and so on in regular order, as described; or two or more nitrating vessels may be employed and preferably fixed at different levels, as will be readily understood by those versed in the art. By working in this manner an increased yield of nitroglycerine is obtained, of full specific gravity and explosive power, without increased quantity of acid beyond that usually

employed, and at only a slightly increased cost for manipulation, which is more than repaid by the increased yield, quality, and safety, as the fully converted trinitro-glycerine is far less liable to spontaneous decomposition than a mixture of such nitroglycerine with lower nitro compounds.

He claims:

1. The improvement in the method of manufacturing nitroglycerine, which consists in first nitrating a charge of glycerine and separating the product from the spent acid, then treating said product anew with a fresh charge of nitrating acid in excess, and finally separating the nitrated glycerine from the fresh excess charge of acid, substantially as described.

2. The improvement in the method of manufacturing nitroglycerine, which consists in first nitrating a charge of glycerine and separating the product from the spent acid, then treating said product anew with a fresh charge of nitrating acid, separating the nitrated glycerine from the acid, and employing the acid to nitrate a second charge of glycerine, substantially as described.

3. The improvement in the method of manufacturing nitroglycerine, which consists in first nitrating a charge of glycerine and drawing off the spent acid, next treating the product with a fresh charge of nitrating acid, then drawing off the nitroglycerine and nitrating a fresh charge of glycerine with the same acid, and repeating the operation in the same nitrating vessel, substantially as described.

The *Scientific American Supplement* **27**, 11070–11071; April 13, 1889, copies from *La Nature* an article by M. Vuillaume, late director of the dynamite factory at Cengio, Italy, on the "Manufactures of Nitroglycerine," which is illustrated by a number of drawings showing the apparatus used and the method of working it.

Eduard Liebert, of Berlin, has been granted two patents for methods of treating nitroglycerine. In the first he seeks to render nitroglycerine uncongealable by adding to it isoamyl nitrate. This addition, while it may not prevent freezing in all cases, is likely to weaken the effect considerably. In the second, he adds ammonium sulphate or nitrate to the acid mixture during nitration, to destroy the nitrous acid formed according to the following equation:

$$(NH_4)_2SO_4 + 2HNO_2 = H_2SO_4 + 2N_2 + 4H_2O.$$

—*Ding. Poly. Journ.* **278**, 19; 1890.

U. S. Letters Pat. No. 449,687, April 7, 1891, have been granted Hiram S. Maxim for "Process of and Apparatus for Making Explosives."—Ill.

His invention relates to the manufacture of explosives of the kind or class known as "nitro compounds" or "nitrated explosives," such as nitroglycerine, gun-cotton, and the like, which result from the combination or composition with glycerine, cellulose, or the like, of nitric acid or other suitable nitrating compounds.

In his specification he describes the invention as applied to the manufacture of nitroglycerine only; but its applicability to the treatment or manufacture of other explosive compounds of a similar nature is to be understood.

The main objects of the invention are, first, to produce any desired quantity of an explosive by a continuous process or operation, and, second, to bring the acid or nitrating agent and the glycerine, or other material to be acted upon thereby, into intimate contact with each other while both are in a very finely divided condition. These objects he accomplishes by bringing the glycerine or other material in the condition of spray into a stream or current of acid spray.

In carrying out the invention practically, the mixing of the nitric acid or nitrating agent and the glycerine is effected by means of an injector operated by cold compressed air or by a cold air blast. The suction produced by the current of air flowing through a nozzle forming a part of the injector, draws the glycerine from a tank in which it is contained, and the current of air impinges upon and atomizes the glycerine, or scatters it in a fine spray. The acid is similarly drawn from another tank and blown into a fine spray, and the two substances while in this finely divided condition are caused to intermingle in the presence of air which is rapidly expanding and of which the temperature is rapidly falling. The atomized acid and glycerine are together blown into, and conveyed through, a mixing pipe or tube, and after issuing therefrom they are washed or quenched by a copious spray or jet of water, and collected in a suitable receiver.

The apparatus, as described, consists of a nozzle entering a "chamber" provided with a nozzle, entering the enlarged end of a "tube," the three concentric parts forming a double injector, of which the inner or first nozzle is connected with a receiver of air compressed by a suitable pump to a pressure of about 100 pounds to the square inch. Which pipe enters the "chamber" back of the orifice of the inner or first nozzle, contains a suitable cock, and leads from

a tank or receiver. A second pipe, provided with a cock, leads from a second tank or receiver and enters the "tube" back of the orifice of the nozzle of the "chamber." One of the tanks is to contain the acid or nitrating agent and the other the material to be combined therewith, and both are provided with glass gauge tubes to indicate the levels of the liquids therein.

The first mentioned "tank" is filled with glycerine, and the other, to the same level, with acid. The air is then allowed to flow through the first or inner nozzle. The current of air issuing from this nozzle produces a partial vacuum in the "chamber," which, upon opening the cock of the pipe connecting with the tank of glycerine, draws the glycerine in. The air impinging upon the glycerine atomizes it and forces it in a spray through the nozzle of the "chamber." The air-jet and spray issuing from this nozzle produce in like manner a partial vacuum in the "tube" back of the orifice of said nozzle, and this draws in the acid, which, meeting the jet, is blown into spray and mixed with the atomized glycerine. The air being kept under a high pressure in the reservoir, a considerable amount of refrigeration will take place in the nozzle of the "chamber" and in the "tube" by reason of its expansion in these places, and the temperature of the acid and the glycerine will thus be prevented from rising too high.

The "tube," into which the atomized mixture of acid and glycerine is blown, serves as a mixing chamber, and should be of considerable length, so that the materials may have ample time while in the same to complete their reactions on one another in the manner required. It may be from 1¼ to 1½ inches in diameter at the part which surrounds the injector nozzle, and for a distance of, say, 16 inches, or thereabout, from the said injector, and may gradually increase in diameter beyond this point until it reaches a collecting tank. It is, moreover, advantageous to arrange said "tube" with a fall toward the collecting tank of about 1 in 15.

The length of the "tube" or mixing pipe may be from 100 to 200 feet, more or less, and a wall or mound of earth may be built between the injector and the collecting tank to serve as a protection to the operator. The "tube," as well as other parts of the apparatus, may be surrounded by a water-jacket, through which a circulation of cool water is maintained for keeping down the temperature of the explosive compound.

Prior to entering the collecting tank the current of spray is met by a stream or a number of jets of cold water from a nozzle inserted in

the top of the collecting tank above the "tube" or mixing pipe, which serves to cool or quench it as it enters the collecting tank.

The tanks for containing the acid and the glycerine are preferably arranged side by side above the injector and mixing pipe or "tube," and should be made of such relative capacities or dimensions that they will contain the required proportions of acid and glycerine, and will therefore both be emptied at the same time.

The quantity of explosive material operated upon at any time is very small. The collecting tank should, however, be of large dimensions, so that it will contain a great quantity of water.

The acids and glycerine being blown into a fine spray, as above described, an instantaneous nitration will be effected, while the expansion of the air, as it issues from the injector, serves to lower the temperature. Moreover, it is claimed for this apparatus that the chemical reaction may be readily controlled, and that, should any undue production of heat take place or nitrous fumes be developed, the supply of air to the injector may be increased and the temperature thus brought down.

In cases where the space available for the apparatus does not admit of the use of a long mixing pipe or "tube," such as is described, the "tube" is carried direct to a tank surrounded by a water-jacket. A pipe leads from this tank, from or near its bottom, back to the mixing chamber or space at the rear of the nozzle of the "chamber." This pipe contains a cock, which, while the atomized acid and glycerine are being mixed, is closed. When a quantity of explosive has been thus made, the acid and glycerine supply pipes are closed and this cock opened. The continued flow of air under pressure produces a rapid flow of the mixture from above pipe back into the collecting tank. The expanding air with its refrigerating effect keeps down the temperature, while by the circulation and agitation the substances are thoroughly and intimately mixed.

An air vent is provided in this collecting tank, and the same disposition as in the previous case may be used for quenching the mixture by jets of water.

The subsequent treatment of the nitroglycerine or other compounds made by this process may be the same as in the case of similar compounds as hitherto manufactured.

What he claims is:

The method or process of manufacturing explosives as described, which consists in separately atomizing or finely dividing the nitrating

agent and the material to be acted on thereby, and uniting the two or causing them to intermingle while in such condition.

The continuous process described of manufacturing explosive compounds, which consists in uniting and causing to intermingle jets of the acid and material to be acted on thereby, in the condition of spray, carrying off the spray in a mixing chamber, and collecting the resulting compound in a tank or receiver.

The method or process described, which consists in atomizing or spraying glycerine by a jet of air under pressure, separately atomizing or spraying in a similar manner a nitrating agent, and mixing the two substances while in the condition of spray.

The method or process of manufacturing explosives, which consists in separately atomizing and uniting the spray of the nitrating agent and the substance to be acted on thereby, and then quenching the mixture with water.

The combination of a nozzle, a receiver or source of compressed air connected therewith, a tube or chamber surrounding the nozzle, a tank or receiver for glycerine connected with said chamber, a second chamber, and a tank or receiver for acids connected with the same, the first chamber being formed with a contracted nozzle that enters the second or mixing chamber, the above parts being arranged in substantially the manner as set forth to constitute an injector for atomizing and mixing glycerine and acid.

The combination, with a collecting tank, a mixing tube or chamber leading thereto, and a nozzle or means of quenching with water an explosive mixture delivered from the mixing tube into the collecting tank, of an injector at the end of the mixing tube, tanks for containing acid and glycerine, respectively, connecting with the injector, and a receiver or source of compressed air for operating the injector.

The combination with a receiving tank and mixing tube or chamber, of two concentric injector nozzles, receivers for containing glycerine and acid, respectively, connected to the chambers surrounding the nozzles in the rear of the orifices of the same, and a source of compressed air, as set forth.

In discussing "Precautionary Regulations during the Preparation of Nitroglycerol," F. Scheiding, *Zeits. f. angew. Chem.*, 1890, 609–613, first suggests that the mixing of the acids should be made in a vessel provided with a cover and chimney for conveying the acid fumes out of the building. The mixing can be effected by means of

compressed air, and the cover prevents any of the acids from being thrown out of the vessel. Montéjus should be made of cast or wrought iron, preferably not lined with lead. Cast iron withstands the action of the acid better than wrought iron, but is liable sometimes to crack, especially when the air-cock is opened. This cock should therefore be placed outside of the building or separated from the montéjus by a wall, and the montéjus should stand clear of everything, so that any leak can easily be observed. In the next operation, which properly may be called dangerous, viz. the nitration of the glycerine, rise of temperature which might lead to explosion may be caused by impure glycerine or the accidental admixture of water. The chemical examination of the glycerine is therefore essential.

The nitrating vessel must be made of thick lead and stand clear on all sides in a well lighted building, yet not exposed to the direct rays of the sun. The contents of the nitrating vessel should be kept cool by several separate coils of thick leaden pipe, through which cold water passes. In order to prevent any water from escaping into the acid mixture, should one of the worms be damaged during the operation, the cooling water should flow from a higher lying vessel and discharge into a lower lying tank. The cooling worm would thus act as a syphon and draw some of the acid and nitrogen mixture into the lower tank, where its presence would be recognized by the turbidity produced, or by means of litmus paper. The agitating or stirring is best effected by compressed air, and the workman should always ascertain by means of a manometer whether there is sufficient air pressure before commencing the nitration. In order that no water may be carried over with the air, a condensation box should be fitted at the lowest point of the air pipe. The nitrating vessel must be provided with a cover or hood and chimney, which will convey the acid fumes out through the roof. The whole apparatus should stand over a large tank containing water, into which the whole contents of the nitrating vessel can be promptly discharged through a large earthenware cock, should the temperature rise to 40° C.

The floor of this building in certain districts consists of sand, in others of clay. The author prefers a clay floor slightly sloping towards a gutter in the middle which passes underneath the door. The floor should be kept always damp and covered with sawdust, and the place where the men stand covered with a soft mat. The mat should be washed twice a week, and the sawdust renewed once a week and the removed sweepings burned.

The author suggests the erection of one or two shelter huts, in which one or two workers could take refuge when an explosion threatens, and be protected from falling pieces. An alarm horn should be hung in the shelter hut, by which a warning signal could be given for the whole factory. As explosions have been caused in other buildings by debris falling through the roof, the author advises that the roofs of the buildings in which nitroglycerine or dynamite is present should be provided with a strong double lining. The intervening space would also keep the building cooler in summer and warmer in winter. An electric bell should be near the nitrating apparatus, by which a signal could be sent to the laboratory in the event of anything unusual occurring during the operation. The plug of the discharge cock should be carefully examined before each operation to see that it is quite free from any grit or frozen nitroglycerine.

For conducting the nitroglycerine and waste acids through the mound surrounding the building, a brick channel thickly covered with tar is recommended, just sufficiently wide to take an open leaden gutter, through which a leaden pipe can be pushed. This pipe can be daily cleansed by rinsing first with concentrated sulphuric acid and then with water.

The author considers the combination of the nitrating apparatus with the separator in one building as injudicious. The separator should be provided with a perforated pipe for compressed air, that in the event of heating taking place, which often occurs only at separate spots, the mixture could be agitated and the danger possibly avoided. It should also have electric thermometers which would ring a bell when a certain temperature was reached. The separator should also have a hood with chimney passing through the roof. Outside of the mound surrounding the separator house there should be a pipe for compressed air, with a cock by means of which the agitation of the liquid in the separator could be started, should the workmen have fled from the building on signs of danger without starting the air agitator. Should the bells in connection with the thermometers cease ringing, the building can safely be re-entered. An essential condition of safety is that all the apparatus should be carefully examined daily, to see if it is in proper working order. After the nitroglycerine has passed to the washing house the most dangerous operations are passed. There the greatest cleanliness should be observed and care taken that no wash water, which always

contains some nitroglycerine, is splashed about. The nitroglycerine must be washed quite free from acid.

Dr. Thomas Darlington, in treating of "The Effect of the Products of High Explosives, Dynamite and Nitroglycerine, on the Human System," says in the *Medical Record* **38**, 661–662; 1890: When dynamite or nitroglycerine is used in open-cut work, as on our railroads, after the explosion the gases immediately distribute themselves in the atmospheric air, and no effect has been noticed on the workmen employed. But when used in tunnels, as in mining or other partially closed cavities, where the gases or residues are slow to escape from the mouths of the tunnel, or up air shafts, serious deleterious effects are produced.

There are, for purposes of study, practically two classes of dynamite, which might be termed inorganic and organic, according to the absorbent used. A type of one class is that made with infusorial earth, and of the other, that made with wood pulp or sawdust. Others still are made from a combination of both. The results of the explosion, however, are practically the same in either case, except that with the organic absorbent we get with the products an additional amount of carbon.

An experience of over five years where such explosives have been in use has led me to believe that an article on this subject might be of interest to some of the medical profession.

During 1885 to 1887, while surgeon to the New Croton Aqueduct, fully thirteen hundred cases of asphyxia, or partial asphyxia, and poisoning, from the products produced by the explosion of dynamite, came under my care; and more recently a few other cases which I have had better opportunity to study.

Two classes of cases were observed: First, where a considerable quantity of the products was inhaled at one time—acute cases; second, where the men constantly breathed a small amount, or chronic cases. The acute cases varied according to the amount inhaled.

In some cases where the amount of dynamite used was not large, or where, after the explosion, a considerable quantity of fresh air has been mixed with products of combustion, or where the workman has after a few breaths become giddy and is pulled away by others and sent to the surface, the effects produced are a trembling sensation, flushing of the face, succeeded sometimes by pallor, frequently

nausea, sometimes vomiting, with throbbing through the temples and fullness in the head as if it would burst, followed by an intense headache characteristic of poisoning by nitrites—similar to that of nitrite of amyl, only not so violent, but more persistent, frequently lasting forty-eight hours. The heart's action is increased, and the pulse full and round, though somewhat compressible.

Case I.—J. C——, occupation miner, while returning to work after a blast, became dizzy, and crawled on hands and knees back to the bucket; felt as if drunk. About twenty minutes afterward was nauseated and vomited slightly. Had a feeling as if his head was swelled. After vomiting the headache increased. The pulse at this time was full and bounding and 108. Ten hours afterward the headache was more pronounced, and the pulse 88 and more compressible.

Where, however, a man goes into the tunnel immediately after the explosion, and is brought in contact with a large percentage of the poisonous materials, the effects are giddiness immediately followed by unconsciousness, and the patient presents the usual appearance of asphyxia. Sometimes in these cases the pulse is full and bounding, though very compressible; but in most of the cases it is alarmingly weak. Generally there is great pallor, though this may be partially due to working underground. The comatose condition soon passes away, and is succeeded by drowsiness, languor, cold perspiration, intermittent pulse, and generally nausea and vomiting. Sometimes the breathing is spasmodic, and frequently there is hiccough, and after a time a severe headache.

Nearly all of these cases, however, no matter how serious they seem at the time, recover; though a substitute on the Aqueduct, during my absence, was on one occasion so unfortunate as to lose two cases. I found upon inquiry that death in these cases occurred several hours after the patients were removed from the tunnel, and was due to paralysis of respiration.

In the chronic cases there are four prominent symptoms: Headache, cough, indigestion, and disturbances of the nervous system.

The cough is similar in character to the cough of pertussis or of malaria, and at first I was under the impression that it was purely malarial, as cases of intermittent fever were frequent. But although some of the cases may have been complicated with malaria, there were many others that were not, in which the cough was persistent.

In nearly all of the cases there was a continuing headache.

Next in prominence to these symptoms come disturbances of the nervous system, as trembling, irritability, neuralgia, etc. In fact, nearly if not all of the symptoms were attributable to this cause. Even the cough, in all probability, was due to the effect produced on the pneumogastric nerve.

One of the superintendents became so nervous and irritable, largely from this cause, that it was with difficulty that he could get along with the men. All of the men affected seemed extremely nervous. And with this was associated indigestion, probably due to the same cause. Of course, with this latter symptom, the character of the food and the manner in which it was eaten must be taken into consideration. But as soon as a man with these chronic symptoms was taken from the tunnel and placed at work on top, he steadily improved, and would finally recover entirely.

It was also noticeable that those who had previously suffered from dyspepsia or neuralgia were made much worse by the dynamite smoke.

One inspector on the Aqueduct was forced to resign by reason of the constant return of an old "tic douloureux," due to this cause. What were the symptoms recognized due to?

The formula for nitroglycerine is $C_3H_5(NO_3)_3$. And the products from the combustion of this are written:

$$4C_3H_5N_3O_9 = 10H_2O + 12CO_2 + 6N_2O_3.$$

In other words, the products are water, carbonic acid gas, and nitrogen dioxide; none of which would produce the symptoms above described except asphyxia, but not the effect on the heart, nor the other symptoms witnessed. What then was the cause?

A comparison of the above symptoms in the acute cases with the phenomena produced by various sized doses of nitroglycerine shows them to be identical. This similarity of symptoms from inhalation of the products of the explosion of dynamite, and of those produced by the nitroglycerine itself, is so well marked that even miners themselves have noticed it. Frequently, when dynamite is frozen, a miner will place a cartridge in his boot to thaw it out; and the absorption of nitroglycerine through the skin will produce precisely the same symptoms as in the mild acute cases of the inhalation of the products before described.

Again, I know an instance of where a miner used his knife to cut a cartridge, and afterward cut and ate an apple with the same knife.

In this case, according to his statement, the symptoms were similar to being "knocked out by powder smoke," only more severe. The headache persisted three weeks. And on another occasion this same miner cut up some tobacco to smoke, with a knife that he had used for dynamite, and was again similarly affected. Here the heat from the tobacco inhaled smoke volatilized the fine particles of nitroglycerine on the tobacco below, and poisoning was produced by absorption through the lung tissue.

No other conclusion can well be reached than the fact that there is mixed with the gases produced, unexploded particles of nitroglycerine in a volatile state, and these particles inhaled by the miners produced the effect described.

There is no doubt but that the explosion of a large quantity of dynamite would produce sufficient gases of CO_2 and N_2O_3 to produce asphyxia. Here we get the cyanosis and other symptoms of simple asphyxia, and we may get nausea and vomiting; but not the same disturbance of the sympathetic system, nor the continued chronic spasms of the vagus, nor the persistent headache pathognomic of nitroglycerine poisoning. This fact can be conclusively proved by waving in the fumes, immediately after an explosion, a cold sheet of glass, and thus collecting upon it by condensation a small percentage of the nitroglycerine itself.

As regards treatment, as a preventative, the use of such apparatus or machinery, whether by blowing or by sucking, as will rapidly clear the tunnel or cavity from noxious gases or fumes is to be recommended. Where steam drills that are worked with an air compressor are used, they contribute largely to this end.

Also it has been found by makers of dynamite that the use of a large cap will explode a greater percentage of the glonoine than a small one, and this, to a certain extent, obviates the trouble. In certain cases, however, for some reason, a cartridge does not explode, but burns like a candle, with considerable sputtering. In such an instance the amount of nitroglycerine volatilized is much greater than if exploded, and consequently the effects far more deleterious. I have witnessed a whole "shift" "knocked out" from this cause.

Of course, such measures as are generally used in cases of asphyxia are of service. But in addition to these, the use of cold to the head, and of atropine, ergotine, or other vasomotor stimulants, administered subcutaneously, are of necessity indicated and exceedingly efficacious. There is little doubt that the effects of nitroglycerine

are produced from its decomposition and the formation of a nitrite in the body. "Treatment with ammonia restores normal color and normal functional power to nitrite-poisoned blood."

Acting on this principle, and from its stimulant properties, I have uniformly treated my cases with inhalation of ammonia, and also given the carbonate and aromatic spirits of ammonia internally; and up to the present time have not lost a case.

It seems to me it would be well for those in charge of such works to recommend to the workmen to carry with them small vials of this remedy for use in similar cases.

In none of the cases did I notice any changes in the blood—that is, darkening—such as are mentioned in nitroglycerine poisoning, but this may have been due to lack of proper observations on my part. In numerous cases of pneumonia the sputum was darker than usual, but this I attributed to the dust and lamp-smoke inhaled.*

According to W. Schuckher's English Patent 45,625, Sept. 16, 1890, for "A Process and Apparatus for the Manufacture of Nitrated Starch," starch, preferably potato starch, is dried at 100° C. and finely ground. It is then dissolved at 20°–25° C. in nitric acid of 1.501 sp. gr., using 10 kilos. of acid to 1 kilo. of starch. The solution is added to a mixture of nitric and sulphuric acids, which, for sake of cheapness, may be the waste acid from nitroglycerine manufacture, containing about 70 per cent of sulphuric and about 10 per cent of nitric acids. Five kilos. of this waste acid are employed to every kilo. of the nitrated starch solution, the mixture being kept at a temperature of 20°–25° C. Nitrated starch is precipitated as a fine powder and is collected on a filter of gun-cotton. The bulk of the acid is then removed from the precipitate by hydraulic pressure. The cakes produced are well washed in water and treated with 5-per cent soda solution. After 24 hours the cakes are ground between rollers, the creamy mass formed being afterwards dried by means of a centrifugal machine or a filter press. Finally about 1 per cent of aniline is added to the residue, which still contains 33 per cent of water. Nitrated starch as prepared dissolves readily in nitroglycerine. In

* Bibliography: Hunt, T. Sterry: Am. Jour. of Sci. and Arts, "Glonoine," Nov., 1849; Murrell, William: Lancet, 1879, pp. 80, 113, 225; Hay, Matthew: Practitioner, June, 1883; Brunton, T. Lauder: Pharmacy, Therapeutics, and Mat. Med., 1888, "Nitroglycerine," p. 788; Curtis, Edward: Reference Handbook of the Med. Sciences, p. 189, "Nitrites."

the cold it forms at first a mass resembling lime, but as more of the nitrated starch is added a hard waxy material is produced.

A very serious accident occurred on the 13th May in a factory at Avigliana, during the manufacture of ballistite, by which 13 lives were lost. Through the Foreign Office we have obtained some interesting particulars of the accident, collected by Col. Slade, British Military Attaché at Rome. It appears that "The factory, or rather the special portion of the scene of the occurrence, is a long roofed structure, divided into five separate compartments, where the operations of milling, cutting, sifting and cleaning are carried out.

"In the first ward the ballistite, by means of a special engine, is prepared in the form of sheets, after being laid in a wooden trough fitted with double zinc plates, and subjected to the heating process by means of hot-water pipes, after which they pass to the cutting machine.

"The second ward was empty at the time of the fire, a large platform being in course of construction for the setting up of two cutting and two grinding machines.

"In the third were several cutting and granulating machines, together with a ton of smokeless powder ready prepared to be despatched to the navy.

"The fourth contained the sifting machine, and it is also supposed that upwards of two or three tons of black powder were also in the ward.

"The cleansing machine and upwards of four tons of black powder, partly packed and partly loose, were in the fifth compartment.

"All the several compartments are connected by vaulted passages, and all have an outlet by means of light glass doors; all these doors were open* when the fire broke out.

"A workman, who was standing about 70 yards off, stated that the fire broke out in the first compartment, and spread with the greatest rapidity through the other four. No dead body was found in the first ward, two were found in the fourth, and eleven crowded together at the door of the last; among these eleven were the remains of a man who at the time was working in the first compartment.

"This leads one to fairly assume that the fire originated in the

* Subsequent information throws doubt on this statement, and it seems more probable that the doors were closed, and they certainly opened inwards instead of outwards.

first compartment, either through the action of the cutting machine, or by the sudden ignition of one of the strips of ballistite through overheating.

"The bodies of the five men working in this ward were set on fire, and the poor fellows, in place of running out through the open door, fatally searched for an escape through the several compartments, thus spreading fire in every direction, to the last room, where the heat must have reached such an intensity as to have produced immediate death. All the tools and wooden implements were slightly charred, whilst the metal of those zinc-plated had completely melted away.

"The various machines did not suffer much from the results of the accident, and will be set at work again as soon as the buildings have been repaired.

"One of the walls of one of the wards was blown down and three were unroofed, the tiles falling outward. The first two wards were left almost intact. The total amount of powder destroyed may be reckoned at about 8 tons, whilst the damage is estimated at about 4000 l."

Although nothing definite is disclosed as to the cause of the accident, there can be no doubt that the manufacture was being carried on in a very dangerous manner, with a wholly unnecessary accumulation of persons and explosive material within a single building, and with a very inexcusable neglect of what in this country would be regarded as essential precautions.

It is most important (especially when dealing with a comparatively new material like ballistite) to isolate the various processes, to subdivide the amounts of material so as to limit the effects of a possible accident, and to allow only a very few work-people within a single building or risk.

None of these things were done here, and the subdivision of the buildings into wards (as the event showed) was entirely illusory.

It has been suggested (by the Italian Director-General of Artillery) that a piece of ballistite in being carried from one machine to another may have fallen off one of the trays, and that some small grit or gravel may have adhered to it, and so bronght about the explosion, when the machinery was again set in motion. This suggestion is not intrinsically improbable, but if it be accepted it would point to an even greater disregard of precautions, because one of the first efforts of the maker of explosives should be directed to the rigid exclusion of grit from danger buildings.

The one satisfactory point in connection with this accident (which in its consequences, if not in its inception, would appear to have been entirely preventible), is, that although no less than about 8 tons of ballistite is estimated to have been consumed, there was no violent *explosion*. This observation usefully supplements the results obtained in the experiments with burning the kindred explosive "cordite," which are described in the Experiment Section of this Report.*—15*th Ann. Rept. H. M. Insp. Exp.* pp. 49–50; 1891.

According to O. Guttmann, *Ding. Poly. Journ.* **278**, 25; 1890, smokeless powders have been the cause of fatal accidents at Spandau as well as at Avigliana, which are believed to have resulted from the fact that the behavior of these bodies, under all conditions of production and with novel machines, is yet but imperfectly known.

Among the accidents by fire or explosion which have come under the notice of the Home Office from January 1 to December 31, 1890, we note the following due to ballistite:

The first occurred Feb. 27, at Factory No. 3, Ardeer, Ayr (Nobel's Explosive Co., Limited):—A small "crack" occurred in the ballistite when between the rollers. The foreman felt as if something had struck his wrist, and a mark was found like the prick of a pin. Whether this was a particle of dry nitro-cotton or minute fragment of iron is unknown. The mark in the sheet of ballistite was as if made by a pin point. No one was killed or injured.

The second occurred at the same factory on March 20:—A sheet of ballistite "cracked" in rolling and was broken, but no damage was done. No one was killed or injured.

The third occurred at the same factory on May 13:—A small quantity of ballistite which was being rolled between steam heated rollers, took fire. No one was injured, and no damage was done.

The fourth occurred at the same factory on May 28:—About an ounce of ballistite exploded in an experimental screw-press, about a pound of finished ballistite being ignited by the explosion. No one was injured, and very trifling damage was done to the machine.

The fifth occurred at the same factory on June 21:—Breech-block

* It is not quite clear what is meant by "black powder," of which 4 tons were said to have been present in the fifth compartment. We conclude that it must have been black ballistite (*i. e.* ballistite treated with graphite), and not ordinary black gunpowder, which must certainly have exploded.

of sporting gun slightly cracked in experimenting with smokeless sporting powder. No one was injured. The accident was due to the detonation of the ballistite charge on firing with an ordinary percussion primer.—15 *Ann. Rept. H. M. Insp. Exp.* pp. 115–143; 1891.

In his "Novelties in the Explosives Industry and Blasting," *Ding. Poly. Journ.* **275**, 111; 1890, Oscar Guttmann says since our last installment the problem of smoke-weak powders has undergone a more rapid development than has ever before been known in the history of explosive agents. The daily papers teem with surprising statements wherein powders of unlike characters are classed in one category, so that it is difficult even for an expert to determine precisely what is meant. Under these circumstances it is the province of a technical paper to give its readers an accurate and extended account of the subject, but unfortunately the restrictions in this instance are of such a nature that only a general picture of the fundamental principles can be given.

It is but a short time since the adoption of magazine and rapid-fire guns was a burning question, and in a certain sense it is yet an open one, but still the powers have equipped their armies with rifles of one-third less caliber than those formerly in use, in order that the already heavily burdened soldier may carry a greater number of rounds of ammunition. This change in caliber necessitated, from the outset, a change in the powder charge, for it was essential that the bullet should have an equal range. Next, as owing to the rapid fire but little time was allowed for aiming the piece, it became essential that the projectile should have a very flat trajectory. This pointed to the use of a very *brisant* powder; but as this would necessitate the use of a very strong piece to resist successfully the suddenly developed pressure, it was agreed that new powder must be less *brisant* and should develop its full power at the muzzle of the piece, giving a high initial velocity with a low pressure.

These conditions obtain equally for small arms as for great guns, but the further development for the two classes is different and the powder problem becomes unlike for the two. Hence, when speaking to-day of the smoke-weak powders we refer principally to the small-arm powder.

Although at the outset it was sought to satisfy these requirements by changes in the composition, method of treatment during manufacture, and in the form of the cartridge, a fresh difficulty was soon

encountered. Even before this "an atmosphere filled with powder smoke" had been no empty phrase, but with the rapid-fire guns it was found that the smoke would be increased so as to be insupportable, and that even the skirmisher would be so enveloped, after a few rounds, especially in calm weather, he would be unable to take aim. Hence a powder had to be invented which burned without smoke, and since this, while theoretically possible, was not so in practice, the powders of this class which appeared were first styled in Germany smoke-feeble powders (rauchschwaches Pulver).

From the preceding it appears that the smoke-feeble powder should satisfy the following requirements:

1. High power in a small space.
2. Low specific gravity (to produce a light cartridge).
3. Low gas pressure.
4. High initial velocity.
5. Great flatness of trajectory.
6. Small development of smoke.
7. Harmlessness of the smoke.
8. Constancy.
9. Safety in handling.

The eighth point demands a thorough discussion, for under "constancy" is to be understood a number of conditions.

We shall see later on that the smoke-weak powders principally belong to the class erroneously styled chemical explosives. The readiness with which such substances are resolved by explosion into their constituents throws a doubt on their constancy under all conditions, and their permanency must be proven under all the extremes of heat and cold, dampness and dryness, blows and shocks, agitation, exposure and the like, which obtain in practice. Again, the tendency, such as has been observed in the black powder, to separate into its constituents when moist must be provided against. No mildew should form upon them as does form on gun-cotton. They should have no action on the walls of the cartridge cases. They should be so insensitive to mechanical influences that they will withstand careless handling in the field.

In seeking for the ideal smoke-feeble powder it was but natural to turn to nitrocellulose. Already for many years wood nitrocellulose, known as Schultze powder, has been employed in England for sporting purposes, and this was followed by E. C. powder,* which

* Ding. Poly. Jour. 249, 456; 1883.

consisted principally of gun-cotton; while more recently a number of other gun-cotton powders have been noticed, principally for use as sporting powders, but were introduced into use only with great difficulty, and the sporting-paper *Field* had frequently to recount accidents caused through the bursting of the pieces.

Owing to the increasing use of gun-cotton for filling torpedoes and shell, the process of manufacture has been so perfected as to yield an explosive whose properties can be maintained nearly uniform. At the same time, owing to melinite, attention has been called to picric acid and its derivatives, and these have been more thoroughly studied.

The use of gun-cotton proper (trinitrocellulose) could not be thought of, owing to the *brisant* action of this body, but it was found that collodion-wool (dinitrocellulose, soluble gun-cotton), which was less *brisant*, could be converted into a nearly homogeneous mass which satisfied many of the requirements of a smoke-feeble powder, but it was still so *brisant* when used alone as to produce too high gas pressures and too irregular initial velocities. Hence the more successful recent powders consist of soluble gun-cotton mixed with other substances which diminish the *brisant* effect, or it is treated in a particular manner to produce the same result. Thus Wolff & Co., in Walsrode, who have been treating gun-cotton for use in shell charges* in a similar manner, treat the collodion-wool with acetic ether, and the thin skin of collodion thus produced retards the rate of burning. A similar process is employed by H. S. Maxim, of London,† who conducts the vapor of acetic ether to the gun-cotton, and when action has taken place, forces the plastic mass through holes into strips, which are then cut into smaller pieces.

Fr. Gaens, in Hamburg (under which name some expect to find the powders produced by the Rottweil-Hamburg factory), dissolves nitrocellulose in acetic ether to form a gelatinous mass, and mixes with 25 parts of the nitrocellulose, 60 parts of potassium nitrate, and 15 parts of ammonium humate (obtained by treating peat with lye); the mixture being then pressed, granulated and dried.

The Nobel smoke-feeble powder ‡ was originally a modification of the camphorated blasting gelatine, but it was found that the camphor was unreliable and required a special purification to secure uniform results. At present, according to private information, this

* Proc. Nav. Inst. 11, 112; 1885. † Ding. P. J. 272, 66; 1889.
‡ Ding. P. J. 273, 67; 1889.

powder consists of 50 parts of nitroglycerine and 50 parts of collodion-wool. It is impossible to produce a gelatine containing so large an amount of nitrocellulose directly, so benzol, in the required proportions, is mixed with the nitroglycerine, and these are sprayed in fine streams on the nitrocellulose. The mixture, after evaporation of the benzol, is then rolled into sheets which are cut into strips and grains. The sheets have a dark brown color and resemble caoutchouc. The powder is more yellow-brown. If a sheet is ignited it burns in layers and emits sparks.

It is interesting to note that in the case of the Nobel powder, nitroglycerine, which is one of the most powerful explosives, is used mainly to diminish the *brisant* effect of the collodion-wool, and also that it does not detonate even under the influence of the primer of the rifle. The impediments which prevented the production of perfectly uniform gelatine are inherent in the manufacture of this powder, and this lack of reliability is no doubt the reason why this smoke-feeble powder, which otherwise possesses so many excellent qualities, has not come into use.

Abel and Dewar are reported to be engaged in perfecting the gelatinization process for the English government, and in manufacturing a powder which is said to have given excellent results. This new powder, called Cordite, is brown in color, and is in the form of cords of the length of the cartridge, which are bundled like fagots.

The Swiss government have already introduced a smokeless powder, P. C. 88 (Powder Composition 88), made by Schenker and Amsler Sohn, which gave with a charge of 2.4 grams in the 7.5 mm. Schmidt rifle an initial velocity of 615 m., with a maximum pressure of 1300 atmospheres.

France has for some time possessed the smokeless powder produced from collodion-wool by Vieille. Austro-Hungary seems recently to favor the powder of Major Schwab, which is described as a dark-gray, coarse-grained chemical product. Belgium is engaged in the production of wood-nitrocellulose. Germany, which has perhaps made the largest number of trials of private powders, is said to have declined to accept any powders produced by private firms, and to have recently rejected a large lot for failing to meet the requirements and for lack of sufficient stability. It is believed that Germany possesses in the powder manufactured by Major-Gen. Küster, at Spandau, an excellent shooting agent.

In general it may be said that no perfect smoke-feeble powder has

yet been invented, each of those known having its weak points, and therefore those governments that are not directly menaced are disposed to await further developments.

Picric acid and its congeners play an important role in cannon powder. It is yet too early to treat of this, because very sensible irregularities are observed in the composition for large charges, and up to the present nothing really good is at hand. In general, guncotton, ammonium picrate and fused picric acid are preferred for projecting and bursting charges.

Since the patents of the different factories seem to conflict, and the different smokeless powders have much in commón, some of the German manufacturers have combined with Nobel, by which all are protected, and through their co-operation *one* satisfactory powder may be obtained.

In the *Journal of the Royal United Service Institution*, London, July, 1891, p. 707, is a paper by Lt. Col. G. V. Fosbery, in which, after referring to the historical development of the magazine gun, he continues as follows in regard to the ammunition which they carry: "Side by side with the change of weapons, a no less important one has been made in the ammunition they carry. That such should have been the case is but the logical consequence of the adoption of the repeater. From the moment this was decided on, it was seen that, in the first place, it would be desirable to reduce the size of the cartridge so as to maintain the handiness of the weapon; and, secondly, to reduce its weight in order that the soldier might carry a larger number—wrongly or rightly supposed to have become an absolute necessity.

"To reduce the *size* of the cartridge, the space occupied by the charge must be diminished, and for this either the present charge must be made to occupy a smaller space, or a more energetic explosive be found. We are thus at once compelled to use either compressed gunpowder, or one of the higher explosives.

"Again, to take largely from the weight, the bullet must be lightened; and here we must be careful. The range of artillery is increasing every day, and the bringing of quick-firing guns into the field is but a question of time. The infantry cannot afford to lose a yard of their range. The sectional density of the bullet cannot, therefore, be lowered—nay, rather needs increasing—and the reduction in weight must be effected by a diminution of caliber.

"Many of us were in hope that this would go no further than to 0.400 inch or 0.380 inch, when a plain hardened bullet could have been used, and a very considerable economy in the price of ammunition been effected. When, however, it came to be seen what velocities, range, and penetration could be got with a thing like this, no bigger than a common pencil-case, the caliber of 0.303 was decided on, and with it, as a consequence, the metal envelope, regarding the cost and other difficulties of which so much has been said. The studies of Hebeler and Guillaumôt, and the practical experiments of Lorentz prepared the way for this or even a greater reduction of caliber; so that, in theory, no risks of mistake were run.

"It may be an open question whether or no at extreme ranges the fire of the new magazine gun will be as fatal as is that of the Martini-Henry, and whether it would be possible with it to inflict on a distant enemy such terrible losses as fell upon the Russian columns in the valleys near Plevna from Turkish unaimed high-angle fire. We all know that a very small and light bullet, having a speed of 1600 feet per second or over, *i. e.* a bullet traveling at so-called *express* speed, will smash bones and tear up and pulverize flesh in a way totally different from the behavior of the same bullet endowed with a lower velocity, and it may prove to be the case that beyond certain ranges, the effects of the new projectile, say on supports and reserves, will be less than those of the heavy Martini bullet in a very notable degree. As, however, we are promised an initial velocity of something approaching 2000 feet per second, no doubt we shall have an extremely flat trajectory and deadly effects for a very considerable distance, and in any case what is true of our own bullet will—so nearly alike are they—be true of every other bullet in Europe.

"At present, so far as is known to me, we are still in search of the ideal explosive; one, in fact, which shall pack into the smallest possible space, develop the utmost energy, and keep indefinitely under all possible circumstances, and until we have found this, or at all events some reasonable approach to it, we cannot with a light heart adopt, as our Continental friends have done, a smokeless powder for the use of our troops. Gunpowder we know all about; it is a good honest mixture, and, sorely tried as it frequently is ashore and afloat, it may be always reckoned on to do its duty so long as we keep it dry. But when we come to high explosives—specially when these are chemical compounds, and from their very nature more or less unstable compounds at that—we, more than any other people, must

exercise the utmost precaution in their general adoption, and be sure that neither the damps and heats of India, the salt air in our naval magazines, nor the cold of Canadian winters, will set these treacherous substances fermenting, decomposing, or exploding. Hitherto perhaps on the whole Professor Abel's powder, cordite, has shown the best all-round qualities, and bids fair for final selection.

"Having thus spoken of the ammunition question, which will, I believe, when fully settled, effect a more marked change in the conditions of war than even the adoption of the magazine gun, I will, if you please, return to the question of the latter."

U. S. Letters Patent No. 456,508, July 21, 1891, have been granted Alfred Nobel for an Improved Celluloidal Explosive and Process of Making the Same.

It is known that the gelatinous compound commonly called "blasting gelatine," and patented by him in 1876, is composed of nitroglycerine and soluble nitrocellulose, the proportions adopted in practical use being from five to seven parts by weight of the nitrocellulose, to from ninety-three to ninety-seven parts of nitroglycerine, to which is added a small portion of nitro-benzol or analogous matter when it is desirable to make said jelly less sensitive to concussion or percussion. This compound, owing to its eminently detonative character, has been extensively used for blasting rock, but has proved altogether too violent in its action for use as a propeller for projectiles.

The object of the present invention is to so modify the explosive character of this compound as to produce from the same materials an essentially new article possessing the progressive explosiveness needed for propelling projectiles. This he effects by employing a process enabling him to incorporate with nitroglycerine a quantity of soluble nitrated cellulose 10 to 20 times greater than that which is contained in his "blasting gelatine," thereby producing a substance which, in its physical aspect as well as in its intrinsic explosive properties, differs widely from the "blasting gelatine," inasmuch as through the horny or celluloidal character which it assumes it is capable of being reduced to so-called "grains" akin to those of granulated gunpowder.

In manufacturing his present explosive, he dissolves in 100 parts, by weight, of nitroglycerine, say 10 to 15 parts, by weight, of camphor, adding thereto as a diluent, say 50 to 100 parts, by weight, of

benzol. To this mixture is added, say 100 parts by weight, of dried, pulped, carded, soluble, nitrated cellulose, such as nitrated cotton fiber. He then mixes the materials until the nitrocellulose has completely absorbed in its pores the aforesaid liquid and until homogeneity is secured. This done, the benzol is evaporated in the open air, or, better, in a closed chamber provided with a cooled condenser, for the purpose of recovering the benzol or the greater part thereof. When the benzol is evaporated, the material thus obtained is passed for malaxation between steam-heated rollers, when it assumes the aspect and consistence of a somewhat soft celluloid. It is then ready to be rolled out into sheets of any required thickness. These sheets he converts into "grains" by cutting them up into cubes or small pieces of any desired shape, which reduction serves the same purpose as granulation for gunpowder.

The addition of benzol, for which may be substituted any other volatile substance having the same property of mixing with nitroglycerine and rendering nitrocellulose insoluble therein, serves no other purpose than to facilitate by such insolubility the equal absorption and distribution of the liquid into the fibers of the nitrocellulose. As soon as the benzol has been evaporated the nitrocellulose begins to dissolve, and when dissolved the compound is treated as already described.

The given proportions of the ingredients are not absolute, but may be varied in a wide measure, the limits of which will be determined by the facility or resistance which the compound offers to its reduction into "grains." Thus if the celluloidal substance contains more that 2 parts of nitroglycerine to 1 part of nitrocellulose, it becomes almost too soft for a substance which has to be used in a granular form; and if it contains as little as 1 part of nitroglycerine to 2 parts of nitrocellulose, the celluloid obtained is more stiff and hard than needed, and is less easy to manufacture than such celluloid containing no more than half its weight of nitrocellulose.

When the celluloidal substance is made to contain more than half its weight of dissolved nitrated cotton fiber, its formation in the manner described becomes somewhat troublesome, in so far as it requires a prolonged malaxation between steam-heated rollers, or similar treatment. In such case he prefers the substitution for benzol of a volatile substance, such as acetate of amyl, or of ethyl or acetone, wherein the nitrocellulose is soluble, and wherewith the nitroglycerine is miscible, and he adds of such solvent the quantity

needed for complete incorporation of the ingredients; the proportion depending on the solvent's volatility and the temperature at which the malaxation is effected; but there is no mistaking in practice the proportion needed, since sufficient of the solvent must be added to obtain a translucent celluloidal substance. Moreover, for practical use the above given proportions of equal parts of nitrocellulose and nitroglycerine plus camphor gave an excellent result, so that the addition referred to of an excess of nitrocellulose, necessitating an extra addition of solvents, will be resorted to only in exceptional cases.

The nitrated ingredients used are to be deprived carefully of adhering acids by proper methods of washing.

Solid powdered substances may be kneaded in by malaxation between steam-heated rollers or otherwise, and the explosive celluloid may be mixed with pulverulent explosives, such as nitrated starch, nitrated dextrine, mealed gunpowder, or picrates; but it may also be mixed, and this is of importance with powdered oxidizers, such as nitrates or chlorates, for the purpose of furnishing the oxygen wanting for complete combustion, and with a view to reduce the cost price of the article.

The celluloidal explosive composed of 100 parts of nitroglycerine, 100 parts of nitrocellulose, and 15 parts of camphor, contains approximately the oxygen needed to convert, by explosive combustion, all its constituent hydrogen into water vapor and all its carbon into carbonic oxide; but to obtain complete combustion and thereby to convert said carbonic oxide into carbonic acid, it would be necessary to incorporate with each 100 parts of the compound about 82 parts of nitrate or chlorate of potash, or 69 parts of nitrate of soda, or 100 parts of nitrate of baryta, or 163 parts of nitrate of ammonia, or 96 parts of perchlorate of ammonia.

Bearing in mind that one part of hydrogen requires for its combustion eight parts of available oxygen, and that each six parts of carbon require for transformation into carbonic oxide eight parts, and for forming carbonic acid sixteen parts of available oxygen, it is easy to calculate the proportions of oxidizing nitrates or chlorates suitable for each particular case, it being understood that the quantity of oxidizers added should not exceed that needed for complete combustion. Also, the quantity of powdered oxidizers which can be added is limited by the capability of easy practical incorporation by malaxation. The more nitroglycerine and the less nitrocellulose it contains,

the more soft and plastic the explosive celluloid becomes, especially when heated, and the greater will be the proportion of powdered substances which can be practically incorporated.

The camphor or other predisposing solvent may be partly, and even almost entirely evaporated without very materially altering the explosive properties. Such evaporation can be effected by long exposure to the air at the ordinary temperature; but it is much quickened by letting a current of air heated to, say 50° C., percolate among the "grains" of the powder. Of course such evaporation reduces the amount of carbon and hydrogen, so that if oxidizing nitrates or chlorates be incorporated with the explosive, their quantity should be proportionately reduced.

This explosive celluloid can be used for blasting rock, in which case the "grains" may be compressed, similarly to gunpowder, so as to form cylinders or pellets suited for miners' use. Such compression may either be effected at a temperature (60° to 80° C.) at which the material becomes sticky, or at the ordinary temperature by slightly moistening the grains with a solvent, such as acetone or an acetic ether. Of course the grains should not be compressed so much as to leave no air space, upon which the quick spreading of the flame depends. The aforesaid powder can be fired without a detonator, thereby completely differing from the so-called "high explosives" now in use.

Whether for blasting or propelling purposes this explosive has always to be used in a granulated state, or so divided as to present a sufficiently large surface for combustion. The size of the grains or particles varies for each caliber of arms and other varied conditions, as is likewise the case with gunpowder; but otherwise the mode of using and firing does not materially differ from that explosive, except as regards suiting the charge to the ratio of power.

He claims:

1. A process for forming hard celluloidal explosives for propelling or filling projectiles, or for blasting purposes, which consists in uniting nitrocellulose and nitroglycerine, in proportions substantially as set forth, by means of a volatile solvent, as acetone, camphor, or the like, and subsequently removing said solvent, and mechanically treating the same, substantially as specified.

2. The hard, horny, or celluloidal explosive in granular form for above purposes, containing nitrocellulose and nitroglycerine, the same being so far solid at ordinary temperatures as to be susceptible of being cut up into so-called "grains."

3. The celluloidal explosive above described, in dense, horny, granular form, solid at ordinary temperatures, composed of nitro-cellulose, nitroglycerine, and suitable oxidants, as specified, and adapted for propelling or filling projectiles, or for blasting purposes.

The following "Experiments to Determine the Liability of Cordite to Explode *en masse*" were carried out on Woolwich marshes on the 21st of October, 1890, by the War Office Chemical Committee on Explosives, in the presence of the Director General of Ordnance Factories, H. M. Chief Inspector of Explosives, and other officers.

1. 100 lbs. of coarse cordite (3 in. diameter and 14 in. in length), packed in a service box (measuring 2 ft. 3 in. × 14 ft. 6 in. × 7 ft. 9 in. deep, and having 1½ in. sides and 1 in. top and bottom), was attempted to be ignited by means of a tube and small priming charge of gun-cotton. But the cordite failed to ignite.

2. Repetition of above, but using a small priming charge of fine cordite (.05 in. diameter and 11 in. long). The whole mass burst immediately into flame, and burned with great and rapid energy and brilliancy. The lid was removed by the energy of the outburst, the screws being drawn, and those on one end bent. The mass burned for about three seconds, and the light was of the most brilliant character.

3. Repetition of No. 1, and with same result. No ignition.

4. Repetition of No. 2. The cordite ignited and burned with great brilliancy and a gush of bright flame for about 7½ seconds. The lid of the box was forced off (as in No. 2), and the screws were drawn, and in some cases bent.

5. A service case (of dimensions previously given) containing 100 lbs. of the fine cordite was surrounded by wood and shavings, which were set fire to. The bonfire burned for 15 minutes, when the cordite in the case ignited and burned, with a great rush of most brilliant flame, for about four or five seconds. Some small pieces of the burnt wood were then thrown to a distance of about 12 yards. An end of the box was forced out. One side was partially forced out.

6. Repetition of No. 5, but using fine instead of coarse cordite. After the bonfire had been burning for seven minutes the cordite caught and went off with a dull, muffled burst which nearly amounted to a mild explosion. There was, however, certainly nothing approaching a violent explosion, as was shown by only one side of the box being displaced.

7. Six service boxes containing each 100 lbs. of thick cordite were placed together, five on end and one on the top; the center box (in lower tier) was set fire to. It burned about six seconds, and upset the side boxes, but it did not throw off the top box; only the box which was ignited caught fire.

8. Five service boxes each containing 100 lbs. of thick cordite (*i. e.*, those which remained from the last experiment) were placed in a pile, two, two and one, breaking joint; and surrounded by wood and shavings, which were set fire to.

After 15 minutes,			1 box of cordite ignited.		
" 15 "	7 seconds,		1	"	"
" 15 "	14	"	1	"	"
" 15 "	21	"	1	"	"
" 15 "	28	"	1	"	"

Each box burned with a bright rush and burst of flame, but without explosion. The boxes were not broken up, and no fragments of the bonfire were projected beyond about 10 paces.

9. A pile of eight service boxes containing each about 75 lbs. (total 600 lbs.) of cordite was surrounded with wood and shavings, which were set fire to. The top box had a hole in it, which was roughly plugged, and this apparently caught fire and burned away non-explosively at 1 min. 10 secs. after the bonfire had been ignited. The other boxes ignited in succession and burned away non-explosively. The times were as follows:

	Min.	Secs.		Min.	Secs.
1st box,	1	10	5th box,	17	25
2d "	1	15	6th "	18	37
3d "	2	2	7th "	21	31
4th "	5	45	8th "	21	33

—15*th Ann. Rept. H. M. Insp. Exp.* p. 80, 1891.

C. Roth, Eng. Pat. 858, Jan. 16, 1890, for "Improvements in the Manufacture or Separation of Ammonium Nitrate and Sulphate or Chloride of Sodium and of Potassium," prepares ammonium nitrate from equivalent quantities of ammonium sulphate and potassium or sodium nitrate, either by heating the aqueous solution of these salts or by melting them at a temperature below that at which ammonium nitrate dissociates. If the aqueous solution be heated to a temperature above 110° C. until practically all the water is driven off (110° C.

being the temperature at which a solution of ammonium nitrate in an equal weight of water boils), or when the salts are heated in the absence of water and the melt maintained at a temperature between 160° and 200° C., sulphate of potassium or sodium, as the case may be, separates out in the solid form and settles to the bottom of the melt, whilst a liquid layer of ammonium nitrate remains above, which can be easily siphoned off or otherwise removed. A solution of ammonium in an equal weight of water, at a temperature of 110° C., is only capable of holding in solution 15 per cent of sodium sulphate and 10 per cent of potassium sulphate, and the solubility of these subtances in ammonium nitrate decreases as the temperature is raised, until at 200° C. (at about which temperature ammonium nitrate decomposes) only traces are held in solution. Ammonium chloride may be similarly used instead of ammonium sulphate, but its greater cost makes it less advantageous.

C. Roth and W. J. Orsman, Eng. Pat. 20,104, Dec. 13, 1889, for "Improvements in the Treatment or Preparation of Nitrate of Ammonium," proceed as follows: To prevent the absorption of hygroscopic moisture by ammonium nitrate, the crystals of that salt are dried by heating to 80° C., and a solution of nitrocellulose "in the various nitro- and chloro-nitro compounds of benzene or of the benzene series of hydrocarbons and their derivatives" is then poured over them, the mixture thoroughly stirred and allowed to cool. This treatment is especially advantageous when the ammonium nitrate is used in the manufacture of explosives.

To Paul Ward and Edward Mammatt Gregory have been granted U. S. Letters Patent No. 454,239, dated June 16, 1891, for the adaptation of a "Composition Suitable for Priming," to the purposes also of detonation, by the addition of a further ingredient to the composition, thus providing a novel, cheap, and effective detonating material, and manufactured at a minimum risk, suitable for use in any fuse or for similar purposes.

They form the chief basis of their explosive composition by the admixture of powdered coke, 2 pounds; amorphous phosphorus, 1 pound; pure chlorate of potash, 75 pounds, with the addition of benzol, chloride of carbon, or acetate of amyl. The amorphous phosphorus and chloride of potash are ground separately in a mortar or other vessel under one of the above fluids. The amor-

phous phosphorus is then submerged with either of the above fluids. Chlorate of potash is then added and the two ingredients are ground together under sufficient fluid to keep the mass from clogging. When this has been done for a suitable time, coke is added in powder and the whole is again ground for a short time. This forms an excellent priming composition, and by the addition thereto of paraffine or common tallow oil the powder will be enabled to cake together after the grinding fluids have evaporated. This reduces its sensitiveness to friction or percussion without detracting from its explosive violence or its sensitiveness to an electric current, and thus constitutes an excellent detonating composition.

They have found that the detonating effects of this compound are most pronounced when it is detonated by the previous explosion of a priming composition occurring at the closed end of a fuse and detonator-case, where the compression of the gases from the exploding priming composition causes intensely rapid combustion and consequent detonation in the detonating charge.

They state the manufacture, as described, to be much less dangerous than where the usual fulminate of mercury is employed, and that the addition of paraffine oil to the composition serves also to prevent oxidation of the ingredients when stored.

They claim a detonating composition consisting of powdered coke, amorphous phosphorus, chlorate of potash, and paraffine oil, substantially as and for the purpose set forth.

U. S. Letters Patent No. 455,332, July 7, 1891, have been granted Joseph A. Hunt, for a "Blast Cartridge." The invention is described as consisting of two parts of a cylinder, which are hollowed out in their middle so that when they are placed together a recess is formed for the reception of the explosive which may be used. These two parts have each in one end a perforation for the insertion of a fuse, and are made with longitudinal and abutting flanges, which, when the explosive is ignited, permit of the two parts flying apart in opposite directions, thus splitting the log, rock, or other analogous substance asunder. It is said that in using this cartridge no tamping is necessary, that a wet log can be split as easily as a dry one, and that this method of blasting is less dangerous than the old methods, in that the cartridge will not jump out of the log when fired. He claims as new the two halves of a cylinder, recessed as above described, each possessing longitudinal and abutting flanges, with a perforation at the end of each for insertion of a fuse.

Commander F. M. Barber, U. S. N., has been granted U. S. Patent 435,788, Sept. 2, 1890, for a "Method of Floating Stranded Vessels," in which, after pointing out that while one hundred pounds of gunpowder or thirty pounds of gun-cotton will infallibly blow a hole in the side of a ship with which it is in contact, yet at a distance of twenty-five feet horizontally, or ten feet vertically, a vessel using such a torpedo will, while receiving a heavy shock, remain entirely uninjured, he claims: The method of floating a stranded vessel or other object by exploding torpedoes or like agents beneath the surface of the water in the vicinity of the same, thereby causing a shock or concussion and at the same time exerting traction thereon, as by hawsers, from a point outside the vessel, substantially as described.

Under the title "Outbursts of Gas in Metalliferous Mines," B. H. Brough gives, in the *School of Mines Quarterly*, **12**, 13–22; 1890, an account of a number of cases in which gas has been liberated in metalliferous mines, and in some of which serious explosions have occurred. He shows that these outbursts of gas are not always due to the same cause, and he gives the following explanation to account for the formation of the gas in the various cases described: 1. The decomposition, in a mine, of timber in contact with water or moist air may produce fire-damp, which would accumulate in cavities that are ultimately broken into. 2. In iron mines when the iron is not entirely in the state of peroxide, water might be slowly decomposed and hydrogen produced. 3. Fire-damp may be liberated from beds beneath the ore-deposit and find its way through fissures into the workings, the gas being given off from rocks enclosing bitumen in the same way as the natural gas of the United States and other countries. At some of the Derbyshire mines the gas is derived from the Lovedale shales, which are of a bituminous character. 4. Fire-damp may be produced from the decomposition of organic matter in the same way as the hydrocarbon met with in salt mines. 5. In some cases explosions have been caused by outbursts of sulphuretted hydrogen produced by the action of acid waters on pyrites ore. 6. The outbursts of carbon dioxide met with at Foxdale, Freiberg, and Massa Maritima, may have been caused by the action of acid water, produced by the oxidation of pyrites, on limestones and other metalliferous carbonates.—*Jour. Soc. Chem. Ind.* **10**, 143; 1891.

An explosion, which in many of its features recalls those of Rochester and Pawtucket,* occurred in Providence, R. I., Sept. 5, 1891, and resulted in fatal injuries to one man, severe to two others, and slight injuries to several others. From the description in the *Prov. Journ.*, Sept. 6, 1891, we learn that private parties have a contract with the city for the disposal of its swill; that as a step in this process the grease is extracted with petroleum-naphtha; that this naphtha is brought once a month in tank cars holding 7000 gallons each; that this naphtha is conveyed from the cars, through a two-inch pipe, 500 feet long, to the works; that on the day of the accident a leak was discovered in the pipe leading from the naphtha tank by which naphtha escaped to the river, and that immediately on discovery the hole was plugged. It was not supposed that any considerable amount of naphtha had escaped, yet, within a few minutes after the hole was stopped, a report was heard from the Woonasquatucket river, and a sheet of flame, followed by a dense cloud of black smoke, was seen to be projected to a considerable height above it. It was found that a pile-driver had been at work in the river, and that the vapor from the naphtha floating by the scow had become ignited at the fire under the boiler.†

The *N. Y. Herald* of Oct. 16, 1891, details the circumstances attending an explosion on board the U. S. S. Atlanta, Oct. 13th, while at sea in a gale of wind, from which it appears that the forward collision compartment being found filled with water through a leak in the hawse-pipe and imperfect closing of the forward hatch, a handy billy was rigged to pump it out, and when after some hours the suction failed, an ordinary lantern was lowered into the compartment to ascertain the cause, whereupon an explosion ensued which resulted in severe injuries through burns to two men, and more or less serious ones to four others; while the collision bulkhead was markedly bulged. A board ordered, of which the writer was a member, found that the collision compartment had been used as a store-room for paint stores in their original packages, and that among them were spar and damar varnishes and Japan dryer, each of which gave off vapors at ordinary temperatures, which formed easily exploded mixtures when diffused through the air, and that this mixing was more readily effected by agitation with salt water under the conditions which prevailed on the Atlanta.

* Proc. Nav. Inst. 14, 165–166; 1888. † Ibid. 20, 291; 1889.

The explosion and fire which occurred June 15, 1891, in compartment No. 73 of the U. S. S. Philadelphia, were traced to a similar source, and the analogy to the Doterel* accident and similar ones pointed out. (*N. Y. Tribune*, Nov. 27, 1891.)

In consequence of this report, the *Brooklyn Union* of Nov. 11, 1891, states that the Secretary of the Navy has issued an order amending paragraph 34 of page 39 of the Regulations of the Navy to read as follows:

"Spirits of turpentine, alcohol, all varnishes and liquid dryers must be kept in metallic tanks or vessels securely stowed away on the spar deck, and they are never to be taken below except in small quantities for immediate use."

According to the *N. Y. World*, Oct. 27, 1891, an explosion of a similar nature occurred at No. 69 Pineapple street, Brooklyn, N. Y., Oct. 26, through which a young girl was seriously, and perhaps fatally burned. It has been found that petroleum-naphtha or benzoline is a most efficient agent for the destruction of moths, and it is a not infrequent occurrence in establishments where furniture is treated, that, since the fabric is not affected by the naphtha, lounges, mattresses, arm-chairs and the like are completely immersed in the liquid, and retained until saturated.

In this instance the upholsterer employed sought to destroy moths which had gotten into the furniture, and to arrest and repair their ravages, but he endeavored to do this by sprinkling the furniture with naphtha, and closing the doors and windows of the room in the dwelling-house in which the articles were. Some time later the child returning from school opened the door between the room with the naphtha-laden atmosphere, and an adjacent one in which a fire was burning in a stove, when the vapor at once ignited and flashed back.

In the *Sci. Am. Sup.* **32**, 13053; 1891, under the title of the Spontaneous Ignition of Carbon Bisulphide, Dr. Max Popel states that in view of the widespread application of carbon bisulphide in extraction processes, and of the frequent explosions and fires which are caused by its spontaneous ignition—*i. e.*, without its actually coming in contact with flame or any red-hot substance—it is of interest to collect and publish all the observations which have been made concerning the causes of such accidents.

* Proc. Nav. Inst. **8**, 313; 459; 671; 1882.

Unfortunately, the nature of carbon bisulphide is by no means thoroughly known; in particular we have no complete data as to its behavior at different temperatures and pressures, mixed with other gases, air, etc., in contact with metals and other substances; and yet a knowledge of these very points is necessary before the substance can be employed with safety. The main difficulty to be met with in the employment of carbon bisulphide is its volatility. Even at a very low pressure (0.1 atmosphere and less) it is quite impossible in an extraction apparatus to prevent its escape by means of taps and the like. Again, the air which is always admitted on filling the apparatus is again drawn out, saturated with the vapor, the loss increasing with the temperature. In the course of some experiments instituted to ascertain the actual amount of material carried away by the air, a spontaneous ignition of carbon bisulphide was observed under the following circumstances: The tube which connected the interior of the apparatus with the air, and which had previously ended near the roof of the building, was bent over and the end allowed to dip about 10 centimeters into a vessel filled with oil. It was found that the oil absorbed the carbon bisulphide almost completely, and that the whole loss, at the temperature of the cooling surface (10°–12° C.), was only very small; but that it amounted to several liters in the course of a very few hours at a temperature of 8°–10° above this. A pressure of about one-eighth of an atmosphere was also set up in the apparatus, owing to the descending path which the air had to take, and to the pressure of the oil, and this, of course, affected the boiling of the carbon bisulphide. In order to remedy this, the apparatus was to be removed and replaced by another arrangement. While a workman on the roof was screwing off the descending arm of the pipe, Dr. Popel stood by the oil flask, which was perfectly cold, as was also the pipe dipping with it, and in order to allow a little more room for the motion of the pipe, he placed the flask at a lower level, when just at that moment the workman informed him that the pipe was beginning to get very hot at the joint. He was about to quit the place and see for himself if this were correct, when an explosion took place in the apparatus, and the oil saturated with the carbon bisulphide took fire. In this case, therefore, the spot at which the ignition started could be determined with a certainty which is rare in accidents of the kind. No external influences were possible, and the idea that the explosion was caused by the absorption of oxygen by the oil and consequent heating is disproved by the fact that the whole remained

quite cool until the actual moment of ignition. The only probable explanation is that the mixture of carbon bisulphide and air was raised to its igniting point by the heat developed in the pipe by the friction at the bend which was being unscrewed. The pressure being diminished by the lowering of the vessel, the flame spread downward and ignited the oil. The actual temperature attained in this case could not be ascertained, but the following experiment shows that carbon bisulphide and air will ignite even below the boiling point of water. A watch-glass containing carbon bisulphide was placed in a new copper oven with smooth walls; explosion took place regularly at 96°–98°; when the walls were covered with a layer of clay this no longer occurred, so that copper seems to have played an important part in the phenomenon. Mixtures of carbon bisulphide and air readily ignite when brought in contact with iron pipes through which steam at 3 to 4 atmospheres (135°–145° C.) is passing. The less carbon bisulphide there is in the mixture the higher is its ignition point and the sharper the explosion.

It is, therefore, necessary, in places where this substance is employed, to cover all steam pipes, cocks and valves with great care, and also to work without any pressure, so as to avoid loss. Unfortunately it is impossible to employ the vacuum, since the escape of the vapor into the pump cannot be avoided, and explosions would be caused by compressing it when mixed with air.—*Chem. Zeit.*

T. E. Thorpe describes in *J. Chem. Soc.* **55**, 220–523; 1889, a lecture experiment on the "Decomposition of Carbon Disulphide by Shock." The apparatus consists of a thick glass tube about 600 mm. long and 15 mm. wide, fitted at one end with a caoutchouc cork, through which pass two stout wires or thin rods. A small brass or iron cup, like a deflagrating spoon, is attached to one wire, and the other wire is bent so as to come within 2 to 3 mm. of the bottom of the cup. About 0.05 gram of mercury fulminate is placed in the cup, the cork is fixed tightly into the tube, which is clamped to a retort-stand and tilted to an angle of 45°; and a piece of paper which is slightly longer than the tube, and which is moistened with carbon disulphide, is placed within the tube, where it remains for a minute or so, when, the tube being practically filled with the vapor of carbon bisulphide, it may be withdrawn. On now passing a spark from a Ruhmkorff coil through the cup, the fulminate will be detonated and will detonate the disulphide, and the internal walls of the tube will become lined with a deposit of soot mixed with mercuric sulphide and

free sulphur. Similar effects are obtained by filling the tube with a mixture of carbon disulphide vapor and nitrogen or carbon dioxide, but in these cases the deposit of carbon is comparatively dense, lustrous and coherent. This forms an easy and safe method for demonstrating the resolution of an endothermic compound by shock.

Dr. Thorpe was led to devise this experiment through an observation made while investigating the sulphides of carbon. Löw had obtained the C_2S_3 by the action of sodium amalgam on CS_2, and Raab had obtained C_5S_2 by the action of sodium alone on CS_2. Dr. Thorpe used the fluid alloy of sodium and potassium, and treated rectified, dehydrated CS_2 with this alloy, when, after a few hours' standing, the alloy was seen to be incrusted with a yellowish-brown powder. On now shaking the bottle to detach the crust, the contents exploded with a loud report, and the operator's hand was coated with a black deposit consisting, apparently, of finely divided carbon. Further experiments showed that the yellowish-brown powder was highly explosive, and that on simply pressing with a glass rod it detonated with even more violence than nitrogen iodide.

He is as yet only able to offer conjectures as to the nature of this powder. It may be a compound of carbon monosulphide and potassium, analogous to that formed by carbon monoxide and potassium.* There is some ground for the belief that the highly explosive character of the latter substance is really due to the formation of potassium acetylide, produced by the action of moist air upon it, for it is well known that when thrown into water it detonates with great violence and with the evolution of acetylene. In the case of the compound formed by the action of carbon disulphide there can, however, be no suspicion of the presence of hydrogen.

Attempts were made to effect the decomposition of the CS_2 by the use of other explosive agents than the yellowish-brown powder and the fulminates, gunpowder, potassium chlorate and phosphorus, potassium chlorate and ammonium picrate, copper acetylide, nitrogen iodide, Berthollet's silver amine, oxygen and hydrogen, and oxygen and carbon disulphide vapor being used, but they had no apparent effect.

In an article on the "Formation and Decomposition of Carbon Disulphide," *Compt. rend.*† **67**, 1251; 1869, Berthelot calls attention

* Proc. Nav. Inst. **12**, 190–193; 1886.

† Bull. soc. chim. **11**, 45; 1869. Chem. Centr. 333; 1869. Wagner Jahr. **15**, 172–174; 1869.

to the fact that Favre and Silbermann obtained 258.5 cal. as the heat of combustion of the molugrams of CS_2, while the same weight of C and S gave only 24.5 cal., yet at a temperature sufficiently high to decompose the CS_2 no explosion took place. In his *Sur la Force des Matières Explosives* **1**, 196; 1883, he gives the heat of formation of CS_2 as —0.55 cal. for the gaseous and —7.2 for the liquid state, and in **2**, 149; 1883, he states that he has detonated the endothermic gases by means of mercury fulminate.

Under the rather inept title, "The Direction taken by Explosives," Charles E. Munroe combats, in the *Illustrated American* 3, 286; 1890, the popular notion that "high explosives explode downwards while gunpowder explodes upwards," and illustrates his argument by photographs of results obtained in practice. One of the most important illustrations unfortunately is presented in the reversed position.

We are indebted to the courtesy of Major J. P. Cundill, R. A., for a copy of the "Addenda to Dictionary of Explosives,"* bearing date of 1890, which brings the literature of the subject as treated in his very valuable work up to date.

M. Eissler, whose "Modern High Explosives" is so favorably known in this country, has published a "Handbook of Modern Explosives,"† which is in many particulars a better book, as it covers more ground and contains fresher data. We understand that owing to existing copyright there are some obstacles to the introduction of the work into this country.

Vivian B. Lewes, "Service Chemistry,"‡ prepared by the Professor of Chemistry at the Royal Naval College especially for the instruction of naval and military men, gives a very clear exposition of the subject of explosives as regarded from a chemical standpoint.

Through the courtesy of M. P. F. Chalon we are in receipt of his "Note sur les Poudres sans Fumée,"‖ which gives an admirable presentation of this subject up to the date of publication.

* W. & J. Mackay & Co., Chatham, Kent, pph. 17 pp.

† Crosby, Lockwood & Son, London, 1890, 8vo, 318 pp., 105 ill.

‡ W. B. Whittingham & Co., London, 1890, 8vo, 521 pp., 56 ill.

‖ Publications du Journal Le Génie Civil, Paris, pph. 15 pp., 1890.

"Smokeless Powder and its Influence on Gun Construction,"* by J. A. Longridge, presents the results of the investigation by a well-known ordnance expert of the data available for smokeless powders by the use of Sarrau's formulas. His conclusions are that smokeless powder has ballistic properties far superior to the old powders; that the erosive action on the guns will probably be less; that its use in existing guns of the new forged steel type will not lead to any considerable increase of ballistic effect *without considerable risk*, owing to the increase of pressure developed in the front part of the chase, although the actual maximum pressure on the gun may be less; that to utilize the high ballistic powers of the new powders very strong guns will be required, and that such guns will have to be much stronger *in front of the trunnions* than those of the new type forged steel guns: that to arrive at very high ballistic results it is not necessary to have guns of inordinate length, but by the adoption of higher initial, instead of low and more uniform pressures, velocities of 3000 feet per second and upwards are attainable with perfect safety. This points, in his opinion, to the wire system of construction, and he urges that immediate experiments be made to enable new ballistic formulas to be constructed, and determinations made of the tensile strain on the chase caused by the friction of the products of combustion.

B. Westermann announces "Methode zur Zerstörung von Felsen in Flüssenmittels aufgelegter Sprengladungen," by Johann Lauer.

Charles E. Munroe has in press Part II. of his "Index to the Literature of Explosives," in which the periodicals indexed in the first part are brought up to 1890; and in addition Dingler's Polytechnisches Journal, Proc. American Chemical Soc., Nicholson Jour., Edinburgh Jour. Sci., and Popular Science Monthly are indexed from date of first issue up to 1890, making in all 843 volumes which have been reviewed.

* E. & F. N. Spon, London, pph. 49 pp., 1890.

PROFESSIONAL NOTES.

DRAINAGE SYSTEM OF U. S. S. MONTEREY.

By A. W. STAHL, Assist. Naval Constructor, U. S. Navy.

The water-tight subdivision which is a prominent feature of all our new naval vessels involves, as a necessary consequence, a more or less elaborate pumping system for the purpose of removing water that may from any cause enter any of the separate compartments. It is not expected that any such pumping or, as it is usually called, drainage system will successfully cope against the volume of water that would be admitted through a large opening in the bottom or side of an unsubdivided vessel. But if the leak be slight, or if the water entering the bilges be that which is used to keep the crankpins or other parts of the machinery from heating, or that due to leakage of boilers, leakage of shaft tubes, or to any other of the many minor causes which exist in every ship, then the drainage system should be able to keep the vessel reasonably clear. In case of serious damage it is the function of water-tight subdivision to localize the effect of such damage and to set a limit to the volume of water that can enter the vessel. As soon as temporary or permanent repairs to the hull have been made, sufficient to prevent the further influx of water, that which has entered is to be pumped out.

Again, in some vessels, such as the Monterey, special arrangements are made for filling the double-bottom compartments with sufficient water to decrease the freeboard in action; and this large volume of water must be pumped out, if need be, with certainty and rapidity. A proper drainage system must then be able to clear any one of the many compartments into which modern ships are divided, and its manipulation and operation should not be interfered with by the fact of there being considerable water in the vessel. While the drainage system thus plays a necessary and important part in all naval vessels, it becomes specially important in vessels of the Monitor type. In such ships the small freeboard restricts the reserve of buoyancy to such an extent as to make it essential that all means provided for clearing the ship of water shall be of the most efficient character. In time of actual emergency the simplicity of such a system plays an important part in regulating its efficiency. A system which might work admirably on ordinary occasions might readily fail by reason of its complexity when the men detailed to operate it were excited by the danger due to the actual occurrence of some serious accident. It must also be borne in mind that in designing any such system, the weights of piping, valves, etc., must be kept within reasonable limits. The general arrangement of water-tight compartments and drainage of same adopted for U. S. S. Monterey, while not free from objections, yet seems to combine the elements of lightness, simplicity and efficiency to such an extent that a brief description of the same may prove interesting to officers of our service.

The Monterey, now nearing completion at the Union Iron Works, San Francisco, is a vessel of the Monitor type. She is 256 feet long, 59 feet beam, 17 feet in depth from bottom of keel to top of main deck at side. Her normal draft is estimated to be 14 feet 6 inches, so that her reserve of buoyancy is

that due to a possible increase of draft of 2 feet 6 inches. She has 83 transverse frames, her inner bottom extending longitudinally from frame No. 5 to frame No. 77, and transversely to the armor shelf or upper longitudinal on both sides. The transverse frames within the limits of the double bottom consist of main angles riveted to the outside plating, reverse angles riveted to the inner bottom plating, and vertical floor plates connecting and riveted to main and reverse angles.

There are six longitudinals on each side of the vertical keel, consisting, like the latter, of a continuous series of plates connected to inner and outer bottom platings by means of long angles. The transverse frames and the longitudinals are firmly united at their intersections by means of angle clips.

Every third or fourth transverse frame and every alternate longitudinal are made solid and water-tight in their connection with each other as well as with the inner and outer bottom platings; the plates of the remaining frames and longitudinals are provided with large lightening holes.

The space between the inner and outer bottoms is thus subdivided into 107 separate water-tight compartments, the actual water-tightness of which has been determined by filling each compartment separately with water under the maximum head that it could have while the ship was still afloat.

Above the double bottom we find a central longitudinal bulkhead, also two longitudinal coal-bunkers and two wing-passage bulkheads. There are also quite a number of transverse bulkheads, and by the intersection of these bulkheads this space is divided into 78 separate water-tight compartments. The fore and after peaks are similarly divided into eight compartments.

Access to the compartments in the double bottom is provided for by means of 99 manholes in the inner bottom plating, and 70 manholes in the water-tight longitudinals, all such manholes being fitted with hinged water-tight covers.

Communication between the other compartments above the double bottom and in the peaks is effected by 11 manholes and 73 water-tight doors, some of the latter being sliding and arranged to be operated from the berth deck, while others are hinged and can only be operated at the door itself.

We have thus a total of 193 separate water-tight compartments, each of which is to be so arranged and connected that it may be pumped clear of water.

The drainage system of this vessel is divided into two main parts: (1) The main drainage system which deals with all the water that is to be pumped from compartments above the inner bottom; (2) The secondary drainage system for pumping out the compartments between the inner and outer bottoms. The principal pipes of both systems extend practically the whole length of the ship, being located within the double bottom and close to the vertical keel, the 11-inch main drain-pipe on starboard side and the 4-inch secondary drain-pipe on port side. At intervals along the main drain-pipe are located five large non-return and stop-valves, each valve being secured by its flanges to the two sections of main pipe between which it lies. Each valve is also secured to the inner bottom plating, a large hole being cut in the latter to correspond to an opening in the top of the valve. These openings are provided with strainers, and it is through them that any free water above the inner bottom finds its way into the main drain-pipe. Certain of the various bulkheads above the double bottom are provided at their lower ends with sluice-gates which are operated from the berth deck, and by means of which any water accumulating beyond them may be sent to the nearest strainer leading to one of the non-return valves.

Along the engine and boiler rooms a short section of 11-inch main drain-pipe also runs along port side of vertical keel, being provided with two non-return valves, so that no arrangement need be made for allowing water to pass through the center longitudinal bulkhead. All the main drain-piping empties into two large wells, one in each engine room, built between the inner and outer bottoms, pipes leading from these wells direct to main steam-pumps and also to the circulating pumps belonging to the main engines.

Between each two consecutive water-tight transverse frames in or near central part of vessel there are six separate water-tight compartments within the double bottom, three on each side of keel, this number being slightly reduced at the very ends of the double bottom. Alongside the vertical keel and at the lowest point of every such section of six compartments is located a strainer box, which is connected by a branch pipe to the secondary drain-pipe running close by. In this branch pipe is a common stop-valve, arranged to be operated from the berth deck, so that each strainer can be pumped from independently. A sluice-gate, also operated from berth deck, is fitted to the vertical keel and to eaeh water-tight longitudinal within each section, so that water from any of the six compartments in the section may drain down to the strainer box. Thus the water from all the compartments of each section is handled by one branch pipe. The secondary drain-pipe is connected directly with two steam-pumps and four hand deck-pumps; but means are also provided for connecting the secondary and main drain-pipes at three points, so that the secondary drainage water may enter the main drain-wells and be pumped out thence by the four steam-pumps connected therewith, and conversely the four hand-pumps can thus be used to assist in pumping from the main drain-pipe. The drainage from the crank pits ordinarily empties by a small special drain-pipe directly into the main wells; but when much oil is being used the crank-pit drainage may be pumped out separately by two small steam-pumps arranged for that purpose.

Sounding tubes are fitted to every compartment, so that the amount of water therein may be at any time ascertained from berth deck. It is to be noticed that the moving of all valves, sluice-gates, etc., and all other operations connected with the drainage are performed at the level of the berth deck, so that the presence of water in or above the double bottom does not interfere with the efficiency of the pumping system. The upper ends of all the rods coming to berth deck are provided with deck sockets, which automatically indicate at all times whether the valves, gates, etc., are open or closed. All pipes make water-tight joints with the water-tight plating through which they pass, and are provided with expansion joints between each two of such water-tight joints.

In the Monterey it was essential to keep the weight of piping, etc., down to the smallest practicable amount, and in view of this fact the system actually adopted and just described seems to combine the various factors of efficiency to a very considerable degree.

THE KURO-SIWO OR CURRENT OF JAPAN.

By J. J. Mahlmann, Harbor Master of Kobe, Japan.

(Translated from Annalen der Hydrographie und Maritimen Meteorologie, by H. G. Dresel, Ensign, U. S. Navy.)

It is generally known that the Kuro-Siwo (black current) has its origin in the equatorial current of the Pacific Ocean. The latter, in reaching the Philippine Islands and islands immediately to the southward of these, breaks up into two branches, of which one turns towards the south along the Australian coast and towards the east. The other branch, called Kuro-Siwo farther to the north, sets towards the northward, passing along the east coasts of the Philippine and Loo Choo Islands, after which it takes a northeast direction, passing along the south and southeast coasts of Japan, continuing its course to the west coast of America. Having its origin in the equatorial stream, the temperature of the Kuro-Siwo is considerably higher than that of the ocean through which it flows. Its limits can therefore be ascertained by temperature measurements. The boundaries, breadth and rate of the current, however, are not constant, being

greatly influenced by the monsoons of the China Sea. The storms in the Pacific also exert a considerable influence on the Kuro-Siwo, frequently causing very marked changes in its direction. During fair weather the Kuro-Siwo runs in a nearly straight line from Van Diemens Straits to Rock Island, touching Osima on the way. During the winter months the current is seldom met with on this line, nor even at some distance to the southward of it, but in the summer during fair weather it can be surely depended upon, with the line from Osima to Rock Island as its northern limit. It is easily distinguished by the presence of seaweed, drift-wood, tide-rips, as well as by the dark color of the current (from which the name Kuro-Siwo) which contrasts vividly with the color of the surrounding sea. From Rock Island the Kuro-Siwo takes a more northerly direction, passes by Nosima Saki, and turns into the northern part of the Pacific Ocean.

For the most part no currents are met with in the waters adjacent to the northern limits of the Kuro-Siwo, but a counter current has been at times observed, as was the case in February, 1879, at which time the sailing ship Sumanura-maru, Captain Spiegelthal, which had lost her masts when distant about 10 sea miles from Osima, drifted 25 sea miles to the west in four days during a dead calm.

The width of the zone lying between the Kuro-Siwo and the coast of Japan varies with the direction and force of the wind. With heavy northern blows it increases; with southerly and easterly blows it decreases. Should the latter winds be of considerable force and long duration, the Kuro-Siwo departs from its regular ENE direction and sets more or less directly towards the coast, where it causes unusually high flood-tides. As under these circumstances the current sets on shore with an appreciably high rate, it has been observed that steamers have been carried 16 sea miles towards the shore in as many hours, so as to make Osima on the port hand instead of on the starboard.

As the south and east winds are generally accompanied by thick weather, the greatest possible vigilance is necessary on passages between Osima and Rock Island. Neglect of this may easily lead to the loss of the vessel, as is shown by the loss of the French mail steamer Nile with nearly every soul on board, on the coast of Idsu. In fair weather vessels have seldom been set on shore by the current.

The zone along the coast in which the local tidal currents occur does not have the same width at all places or at all times. It extends seaward for 5 or 6 miles, and at the capes and promontories its width is only half a mile. As a rule, the velocity of these tidal currents varies inversely as the breadth of the zone; the smaller the width the greater is the rate of the current. At times the flood-tide has not occurred at Osima, probably because the Kuro-Siwo in striking this cape sets directly across the path of the flood, or because at this time the flood sets through the channel between Osima and the main island.

The flood-tide runs along the coast in a westerly direction and enters the deep bays along their west shores, while the ebb sets out along their east shores.

While running along the coast between Osima and Rock Island, one should try as often as possible to discover whether the vessel is being set on shore, especially with northerly and easterly winds and falling barometer. On the passage from Yokohama to Kobe, in case the weather permits it to be done, the course after passing Rock Island should be laid near enough to the coast so as to skirt the boundaries of the zone of tidal currents. The danger of being set on shore is thus avoided, and the advantage obtained of being able to fix the vessel's position before the weather becomes thick. The distance of the course along the coast line varies but slightly from the distance corresponding to the direct course. The former course approaches the great circle arc between Rock Island and Osima.

In case the inshore course cannot be made, one should steer from Rock Island so as to make Matoya Light. Bearings of the latter will show whether

the vessel is being set ashore. If the weather becomes thick, after sighting Matoya, there is no longer any danger of being set on shore, as the distance from Matoya to Osima is short. As soon as Matoya Light is made, which is visible at a distance of 16 miles, the course must be laid so as to clear Osima.

THE ARMOR TESTS.

[*Iron Age*, December 10, 1891.]

VERDICT OF THE ARMOR BOARD.

After careful consideration of the results of the firing upon the six plates, it is the unanimous decision of the Board that they be placed in the following order of merit, viz:

1. The high-carbon nickel steel Harvey plate furnished by the Bethlehem Iron Company.
2. The high-carbon nickel steel plate furnished by the Bethlehem Iron Company.
3. The high-carbon nickel steel plate furnished by Carnegie, Phipps & Co.
4. The low-carbon nickel steel Harvey plate furnished by Carnegie, Phipps & Co.
5. The low-carbon nickel steel plate furnished by Carnegie, Phipps & Co.
6. The low-carbon steel Harvey plate furnished by the Bethlehem Iron Company.

The right side of Plate No. 1 showed very remarkable qualities. The two projectiles which struck that side penetrated not more than seven inches, the head remaining in the plate, completely filling the hole and with the appearance of having been welded to the surrounding metal, while the body was shattered into many fragments.

No cracks were made on that side of the plate.

The back of the plate on that side showed no disturbance except a hardly noticeable swelling on the surface.

It is to be noted that the upper part of plate No. 6 (Harveyed) showed qualities resembling those of the right side of No. 1, while, on the other hand, Plate No. 4 (likewise Harveyed) was totally lacking in such characteristics.*

Plate No. 2 showed a great degree of uniformity as well as resistance to penetration.

The small penetration of the 8-inch shot in Plate No. 3 is, in the opinion of the Board, due to the excessive upsetting of the projectile.

All of the armor plates were more or less cracked through, but only two, Nos. 3 and 6, badly, and these two plates alone showed cracking before the fifth shot. Plates Nos. 1, 2 and 3 kept out all the projectiles; No. 4 was perforated by one, and Nos. 5 and 6 by two projectiles each.

It will be noticed that the "high-carbon" plates show better results than those of "low-carbon," but it is believed that the chemical analyses of the plates now in progress will show that the words "high" and "low," employed by the manufacturers, have been used arbitrarily and have but little value for purposes of comparison.

The Holtzer and Firminy projectiles were part of the lot used at the Annapolis armor trials of last year.

Comparing the plates of this trial with the Creusot steel and the Creusot nickel steel plates of the Annapolis trials of September, 1890, the Board is of the unanimous opinion that—

No. 1, the high-carbon nickel steel Harvey plate furnished by the Bethlehem Iron Company, and No. 2, the high-carbon nickel steel plate furnished by the

*The method of tempering at Bethlehem differed from that at Pittsburgh.—Note by Departmental authority.

Bethlehem Iron Company, are superior to the Creusot steel and nickel steel plates of last year.

In this connection it should be considered that the firing at this year's trial was more rapid than at last year's, and that the interval between the fourth and fifth shots at each plate was about two hours instead of four days, as then. At this trial the plates were still "singing" from the blows of the 6-inch when they were struck by the 8-inch projectiles.

The Board will, in obedience to the Department's order, make a supplemental report upon a "high-carbon nickel steel Harvey" plate, and a "low-carbon steel Harvey" plate, to be furnished by Carnegie, Phipps & Co., which will be tried as soon as ready under the same conditions as the six plates whose trial has been completed.

OPINION OF THE SECRETARY OF THE NAVY

is summarized as follows:

"By far the most momentous question which the Department has had to consider in connection with the construction of the new navy is that of armor: 1. to secure a supply of American manufacture, and, 2. to determine what kind of armor should be adopted, having reference both to its composition and mode of treatment.

The experiments made last year at Annapolis, described in the annual report for 1890, consisted of a test of the two principal foreign types of armor, the English compound plate and the French all-steel plate, and an entirely new plate, also made in France, upon the special order of the Department, of nickel steel. The result of the trial showed that the compound plate was decidedly inferior, and that as between nickel steel and all-steel the former had distinct and positive advantages, the all-steel plate being broken into four pieces while the nickel plate remained absolutely uncracked.

A series of tests made during the following spring and summer confirmed the conclusions formed at the Annapolis trial as to the superiority of nickel steel, and the Department accordingly decided to adopt it and made arrangements with the contractors looking to that end.

It remained, however, to give a thorough trial to the first armor of domestic manufacture before beginning to place it upon vessels, and for this purpose it was decided to order typical plates, which should be made the subject of an experimental test. This trial was to ascertain two points: 1. whether our domestic manufacturers could produce an armor that would stand competition with the material manufactured abroad, and, 2. which of the various modes of treatment suggested would give the best results. In reference to the latter point the questions to be considered were the relative merits of rolling and forging in the manufacture, and the effect of a new method of treatment, named, from its inventor, the Harvey process, designed to harden the surface of the plate while retaining the toughness of its body.

Of the six plates tried, three were furnished by the Bethlehem Iron Company and three by Carnegie, Phipps & Co.

In these trials, which took place at Indian Head on October 31 and November 14, the plates were subjected to tests more severe than had ever been applied to any foreign government trials. Four shots were fired at each plate from a 6-inch gun with an impact velocity of 2075 feet per second, and an energy of 2988 foot-tons, using the Holtzer projectile of 100 pounds. One shot was then fired at the center of each plate from an 8-inch gun, with an impact energy of 4988 foot-tons, using Firminy and Carpenter projectiles of 210 and 250 pounds weight, respectively. The plates were placed normal to the line of fire.

The results of the trial were in the highest degree satisfactory. Each of the six plates manufactured in this country was superior to the English compound plate, while the nickel Harveyed plate and the high-carbon nickel plate were

superior to all the foreign plates of the Annapolis trial. They may, therefore, be pronounced in advance of the best armor hitherto manufactured in Europe.

Further light was thrown upon the question of the relative merits of all-steel and nickel-steel armor, and any doubt which may have remained upon that subject was finally set at rest. Of the three plates made by Bethlehem two were of nickel steel, one treated by the Harvey process, the other not, and the third was of all steel, Harveyed. Both the nickel plates proved to be far superior to the all-steel Harveyed plate, notwithstanding the advantages which it may have derived from the special treatment, and both proved superior to the French all-steel plate tried at Annapolis.

A third nickel plate, manufactured by Carnegie, under the rolling process, also showed a marked superiority over the all-steel plate of this year, and both it and the corresponding Bethlehem plate manufactured under the hammer showed a capacity of resistance to perforation fully 10 per cent greater than that of the French all-steel plate. In this respect the results furnished by the two American plates manufactured by the different processes (forging and rolling) proved to be remarkably uniform, the 6-inch shots that were fired at them differing in penetration but an inappreciable amount.

The trial thus definitely establishes the fact that armor of excellent quality may be produced by the rolling process, and that forging by means of the hammer, the greatest source hitherto of expense in manufacture, is no longer to be regarded as an absolute necessity. The importance of this fact can hardly be overestimated, for it raises a probability that within a year or two the armor-producing capacity of the United States may be quadrupled in case of necessity, and that if we had 10,000 tons to let and could give 18 months from date of contract to commence delivery, the cost of manufacture would be reduced from 25 to 33 per cent, while the work hitherto confined to two firms would be thrown open to a large number of competitors.

Finally, the trial shows that the high-carbon nickel Harveyed plate is undoubtedly the best armor plate ever subjected to ballistic test.

It may be assumed that the principle of supercarburizing steel to a considerable depth has passed beyond the experimental stage. The question of tempering or chilling the carburized armor plate needs, however, further experimental development, and the lack of uniformity in results, indicated in the Indian Head armor trials, may probably be ascribed to this want of experience. The assurance of success, however, is so great as to warrant the Department in making further experiment in this direction, with every reason for anticipating a completely satisfactory result."

A Course of Instruction in Ordnance and Gunnery, U. S. Military Academy. By Captain Henry Metcalfe, Ord. Dept., U. S. Army. Second edition, 1891. John Wiley & Sons.

This book is used as a text-book at the U. S. Military Academy in the course of instruction in Ordnance and Gunnery, and comprises a full treatise, so far as principles are concerned, on those comprehensive subjects. The chapters are conveniently subdivided by headings to paragraphs, which plan greatly assists the student and instructor. Numerous examples are inserted in appropriate places for solution. The plates are published in a separate volume, a feature which is sometimes considered an advantage. R. R. I.

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UNITED SERVICE GAZETTE.

DECEMBER 5 AND 12, 1891. The battle of Beaumont. The right of naval officers to resign. Naval notes: The Russian navy; French naval budget for 1892; Trials of the Eclair. The health of the navy, I. and II.

DECEMBER 19. Diagrams showing sea commerce and naval expenditure. The new French law on espionage. Armor-plate trials. Naval notes.

The new scheme of training seamen in gunnery is now in full development at Devonport, fully 550 men being now under training in the Cambridge. Under the new system all seamen are required to go through a course of 28 days' instruction in the gunnery ships, and an examination is to be held at the end of their course to determine whether further instruction is desirable. Those who display sufficient knowledge continue in the gunnery ships for another fifty days' training, and are then examined for the rating of seaman gunner, which carries with it the pay of 4*d.* a day extra. Efforts are being made as far as possible to supply newly-commissioned ships for foreign service with men who have been trained in gunnery.

Proposals of re-organization of the French naval engineer corps. Supplement: The truly perilous state of Great Britain should war occur between France and ourselves.

DECEMBER 26. Cadet-ship in the Royal Navy. Launch of the Montgomery. The United States new navy.

JANUARY 2, 1892. The ambulance in war. The United States navy. Russian field-mortar batteries.

JANUARY 9. Snow parapets.

The experiments on the resistance of parapets of snow to field-artillery projectiles were continued during 1891 in Russia. The results showed that plugged shell would pierce 18 feet of snow; that 22 feet of rammed snow and 25 feet of loose snow would give cover to field-artillery projectiles; that splinters of shell did not penetrate more than 20 feet; that it is extremely hard to lay accurately at snow works. The results indicate the best form of snow parapets as one of loose snow 25 feet thick. The range was 700 yards.

Spanish quick-firing guns.

JANUARY 16 AND 23. Naval *vs.* mercantile engineers. Training troops for battle. Gun trials at Portsmouth. French torpedo-depot ship Foudre. Sir Frederick Roberts on musketry.

JANUARY 30. The earnest appeal on behalf of the rank and file of the Royal Navy. Quick-firing guns in the Navy. H. G. D.

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DECEMBER, 1891. The question as to the military-political situation in the Mediterranean Sea. A light-cavalry regiment on active service. Mounted infantry patrols the necessary results of our present system of fighting. An artillery practice game. Note on some recent experiments with the submarine sentry.

JANUARY, 1892. Notes on organization and training. Notes on the attempted invasions of Ireland by the French in 1796–98. The reconnaissance work of the Home District Tactical and War Game Society. The naval schools of the chief Continental powers. The training of the seaman *personnel* in the German navy.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

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THE UNITED SERVICE.

DECEMBER, 1891. Education in the army. The United States steamer Michigan and the lake frontier during the War of the Rebellion. Marshal Augereau. The night express. Personal recollections of Sheridan's raid. History of the United States frigate Constitution (continued). An omitted Napoleonic chapter.

JANUARY, 1892. A word on the artillery question. History of the United States frigate Constitution (concluded). Colonel Burnaby's parents. The experiences of a staff officer in time of war. Should our harbor defenses be controlled by the navy?

FEBRUARY. The education of officers for the armies of to-day. Romance and rebellion. For the best interests of the service. Blockade-running. La haute école.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

NOVEMBER, 1891. Mounted infantry. Formulas for penetration of armor. Compilation of facts relating to high explosives. Post schools. The magazine staff and ammunition service in a sea-coast fort. Battle tactics. Artillery service in the War of the Rebellion. Some principles of organization of our coast artillery. Comment and criticism: The summary court; Range and position finding.

JANUARY, 1892. The terrain in military operations. A United States army. Rapid-fire guns. Discipline and tactics. Reminiscences of Tonquin. Comment and criticism: Magazine and ammu-

nition in a sea-coast fort; Mounted infantry; Battle tactics. Reprints and translations: Smokeless powder; Letters on infantry, XIII.; Service range-finding; Infantry attack; Artillery questions of 1890. Military notes: The Berthier rifle; Inspection report on British cavalry; The artillery of the future and new powder.

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LECTURE XII. Ambulance organization, equipment and transport for the mounted service.

LECTURE I. The organization and equipment of harbor defenses.

MILITÄR WOCHENBLATT.

OCTOBER 3, 1891. The French Soudan. Manœuvres at night-attacks on fortifications in Warsaw.

OCTOBER 7. The battle of Wörth. Experiments with carrier pigeons.

OCTOBER 10. The battle of Wörth (concluded). Review of the latest military inventions. Camp Crassnoe Selo. Armor tests in Japan.

OCTOBER 14. The field-piece of the future. Drills of sappers on the Veva.

OCTOBER 17. Max Jahn's history of military sciences. Military operations in East Africa. Steel turrets for Denmark. Walls of Toulon.

OCTOBER 21. Operations in East Africa, II. Bicyclists in the French army. (According to *La France Militaire* the number of bicyclists in the army is about 10,000.) Trials with smokeless powder in the United States.

OCTOBER 24. Operations in East Africa, III. Manœuvring divisions in the Russian army.

OCTOBER 28. Military society in Berlin. Operations in East Africa, IV. Trial of a 5.3-cm. rapid-fire Gruson gun. New Italian cavalry drill regulations governing the attack. Experiments in crossing rivers at Camp Kiev. French army manœuvres in 1892.

OCTOBER 31. Fighting tactics. Italian cavalry drill regulations governing the attack (concluded). Trials of Hotchkiss rapid-fire guns in France.

The Hotchkiss Company held a trial recently with their 47, 57, 76 and 100-mm. rapid-fire guns, during which several sorts of black and brown powder were compared with several kinds of smokeless powder (BN) in reference to muzzle velocity and gas pressure. For measuring the velocities taken at 40 meters from the muzzle, two chronographs, Le Boulenger and Breger, were used, which worked simultaneously through independent circuits. The pressures were measured by pressure gauges at the breech, and part in the bottoms of the cartridges. The results, which with equal pressure gave an average of about 100 meters in the muzzle velocity in favor of the smokeless powders, are shown as follows:

Gun.	Powder.	Weight of charge. Kg.	Weight of projectile. Kg.	Maximum pressure, atmospheric.	Muzzle velocity. Meters per second.
47 mm. heavy	C2	0.780	1.50	2320	610
	BN	0.425	1.50	2400	720
57 mm.	C brown	0.925	2.72	2420	600
	BN	0.465	2.72	2420	650
65 mm.	C brown	1.650	4.00	2420	630
	BN	1.025	4.00	2420	725
76 mm.	SP	3.200	6.40	2420	620
	BN	1.800	6.40	2320	735
10 cm.	SP	5.500	15.00	2370	565
	BN	3.100	15.00	2370	670

NOVEMBER 4. On military hygiene. Minor notices: English guns built in 1890; French recoil system for field-pieces.

NOVEMBER 7. Military hygiene (continued). Moltke's military works. Assignment of French naval battalions. New torpedo and gunnery school in Italy.

NOVEMBER 11. Military hygiene (concluded). The new Swiss military rifle. Fortifying Belforte.

NOVEMBER 14. The field-piece of the future. The 8-mm. Maxim gun in the Austrian army.

NOVEMBER 18. Observation ladder for field artillery. Competitive firing between artillery and infantry in Italy.

NOVEMBER 21. Heavy rapid-fire guns, II. Description of Canet rapid-fire guns. Drills and manœuvres at Camp Vladikawkas. French Mediterranean fleet.

The French fleet in the Mediterranean for 1892 is to consist of an active squadron in three divisions under one vice- and two rear-admirals, viz: 9 armor-clads, 4 cruisers, 2 torpedo cruisers, 3 avisos, 5 sea-going torpedo-boats, or 23 vessels in all. 2. A reserve squadron in two divisions under one vice- and one rear-admiral, viz: 6 armor-clads, 3 cruisers, 1 torpedo cruiser, 2 torpedo avisos, 12 vessels in all. This gives in all 35 war vessels, viz: 15 armored ships, 10 cruisers of different types, 5 torpedo cruisers, 5 sea-going torpedo-boats. In addition there are 15 war-ships lying in reserve at Toulon which could be ready for service within 14 days' notice.

NOVEMBER 25. Study on the war. On the autumn manœuvres on the east boundaries of France. Failures of English guns of large calibers.

NOVEMBER 28. Equipment of infantry.

DECEMBER 2 AND 5. Equipment of infantry. Heavy rapid-fire guns, III. Statistics on suicides in European armies. Military notes from Holland.

DECEMBER 16. French views on the influence of smokeless powder upon the tactics of field artillery. Gruson trials.

DECEMBER 19. The field-piece of the future.

DECEMBER 30. Military telegraph systems.

JANUARY 2 AND 6, 1892. Studies on the battle of Wörth. Tests of smokeless powder.

Important tests of Nobel powder have been concluded by the Krupp works. The object of the tests was to determine the deterioration, if any, in the powder caused by prolonged exposure to the atmosphere, as well as the effect of high temperature. To test the influence of the air, two kilograms each of several grades of the powder were stored for a year in such manner that the air had free access and could make its influence freely felt with every change in the weather. Accurate weighings were made every four weeks and recorded. At the expiration of a year the differences of these weighings varied from —1.6 grams to +1.6 grams, *i. e.* the powder lost or gained in dampness an amount equal to .08 per cent of its weight. The differences in the relative dampness of the different powders varied during the year from .14 to .24 per cent. Compared with ordinary powder, these results are highly satisfactory; in the latter the variations were at least five times as great. The coating of the grains with graphite was also of advantage, as the variations were least in powders so treated.

The injurious and, in fact, dangerous effect of prolonged exposure to heat is well known. Krupp shows conclusively by his tests that this danger does not exist in the smokeless powder. The powder was exposed first for a period of four days, and again for a period of fifteen days to a temperature of from 40° to 60° C., so that the metal cases containing it became so hot that they could not be handled with bare hands. On trial in an 8.7-cm. gun it was found that the initial velocity of 624 m. per second with powder at normal temperature (17°) rose only to 645 m. per second. The gas pressure increased only from 2320 to 2560 atmospheres. It is important to note that no exudation of nitro-glycerine took place during the heating.

The tests have proved the powder to be well fitted for use in war.

JANUARY 9 AND 13. The battle of Wörth (concluded). The Berthier rifle. Notes on the fighting tactics of General Ferron.

JANUARY 16 AND 20. The howitzer *vs.* ordinary field-piece. Test of nickel-steel plates in France. Growth of Russian railroads in 1891.

H. G. D.

DEUTSCHE HEERESZEITUNG.

OCTOBER 24 AND 28. Russian railroads from a military point of view (continued). New Italian rifle. Apyrite. Trial trips of two new Russian gunboats.

OCTOBER 31. Russian railroads (continued). The Maxim gun in the East African campaign. Rifles for the Russian army. Launch of the Brennus. Trials with the Snyder dynamite projectile.

NOVEMBER 4. Russian railroads from a military point of view (concluded). Comparison between European fleets. Optical firing in France.

NOVEMBER 7. Study of the Franco-Prussian war. Increase of the 6th French army corps. Result of the Zelewski expedition. Smokeless powder in the Swiss manœuvres.

NOVEMBER 11. The military forces of Corea. Transport of explosives in Germany.

NOVEMBER 14 AND 18. Strengthening Biserta. Budget of Austrian army and navy for 1892.

NOVEMBER 21 AND 25. Ship-building in France. Accidents with Nordenfeldt rapid-fire guns.

DECEMBER 9. Increasing the *personnel* of the German navy.

DECEMBER 23. New dry-dock in Kiel.

JANUARY 1, 1892. Krupp field-pieces in China.

JANUARY 6 AND 9. Infantry attack and infantry fire during the advance. The new rifle in Russia. Twenty-four hours of Moltke's strategy.

JANUARY 13 AND 16. Strengthening the French army. Trials of Krupp rapid-fire guns. The Graydon torpedo gun.

RIVISTA DI ARTIGLIERIA E GENIO.

OCTOBER, 1891. The development of field artillery. Upon the quartering of troops. Machiavelli and firearms.

NOVEMBER. The field-piece of the future. On the angle of elevation and its measurement.

DECEMBER. New and worn-out guns in field batteries. Stability of beams uniformly loaded. Extension of the ballistic formula.

RIVISTA MARITTIMA.

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H. G. D.

NORSK TIDSSKRIFT FOR SOVAESEN.

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VOLUME III. Prize essay. On certain exhibits at the Naval Exhibition in Chelsea. Yachts. On the naval administration of England. Bursting of a Krupp 15-cm. gun. The new French armor-clad, Brennus. H. G. D.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

19TH ANNUAL SERIES, VOLUME IX. Notes on Spalato and Suva. Sailing directions for several regular routes. Report of a voyage from Cardiff to St. Rosalia, Guaymas, Pichilingue, and return. Voyage from Newport to Buenos Ayres, Barbadoes, New Orleans, and return to Bremen. The steamer routes from the Cape of Good Hope to Australia. The Kuro-Siwo or Japanese current. Contributions on the hydrography and topography of Onega Bay. Minor notices: Use of oil in quieting the sea; Sailing directions for Leith anchorage; Shehr and Macalleh on the south coast of Arabia; Navigation in Spencer Gulf, South Australia; Description of Lang-Kat river, Sumatra; Sailing directions for Makuny harbor, Pescadores Islands, China.

VOLUME X. Experiments with oil in quieting the sea. Remarks on the Tonga Islands. Remarks on voyages from Hamburg to Chili. Deep-sea explorations in the Ionian Sea and along the north coast of Africa. Deep-sea soundings in the Atlantic Ocean. Tides and currents in New York harbor and neighboring waters. Charts of magnetic elements for 1890. Quarterly weather review of the German Naval Observatory, spring of 1887. Minor notices: Use of oil in smoothing the sea in connection with a life-raft; Notices on the harbor of Santa Cruz, Teneriffe, Tarrafal Bay, Cape Verde Islands; Sailing directions for Bulari passage, New Caledonia; Quick voyages in the higher latitudes of the Indian Ocean.

VOLUME XI. Agreement of weather characteristics in northern Germany. Sailing directions to Port Jero and Port Kalloni, Mytilene. Voyages of the German ships Columbus and Eleanor Margaret from the Atlantic Ocean to Yokohama. Sailing directions for the mouth of the Deli, east coast of Sumatra. Deep-sea soundings in the Pacific Ocean. Quarterly weather review of the German Naval Observatory. Minor notices: On cooling drinking water in the tropics on board ship; Meteorological conditions in February and March, 1889, near the coast of Ecuador; Callao; Hygienic conditions of Rio Janeiro; Warning against use of the chart "Leadenhall Street" of Wilson, west coast of Australia. H. G. D.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XIX., No. IX. On the launching of automobile torpedoes by means of powder, by Julius Heinz, captain, Imperial Navy.

Study on the rational oiling of ship's engines (extract from report of Chief Engineer G. Fontaine, French navy). Night signals, by Ensign A. P. Niblack, U. S. N. The French naval manœuvres, 1891. Ribbed fire-tubes for boilers. The new German line-of-battle ships. The Chilian war. Reconstruction of 35-meter French torpedo-boats. The Goubet submarine boat. Chronometer escapement. Bursting of an English gun. Automobile torpedoes in the United States. Launch of the Spanish torpedo-boat Rapido. Optical firing.

No. X. Consideration of the loxodromic curve from point of infinitesimals. On the launching of automobile torpedoes by means of powder, by J. Heinz (concluded). The artillery and torpedo school-ship of Italian navy. On a new invention to lessen vibrations of small lightly-built ships. The battle-ship of the future. English and French cruisers. The Sims-Edison torpedo. Brazilian school-ship. Launch of the English cruiser Endymion, of the German armor-clad Frithjof, of the Spanish cruiser Alfonso XIII., and the Galicia. Aluminium boat at the Frankfort exhibition. Testing the launching apparatus of the English ship Vulcan. Armor trials in the United States. A new range-finder for coast defenses.

No. XI. On the English fleet manœuvres, 1891. Determining position by Sumner's lines. On the tactics of torpedo-boats. On rapid-fire guns of large calibers. New harbor-defense booms. Tests of Snyder dynamite projectiles. Tests of nickel plates. The French line-of-battle ship Brennus. Floating supply stations for electric boats. Bursting of a Krupp 15-cm. gun. Canet rapid-fire guns of large calibers. H. G. D.

ELECTRICAL REVIEW.

VOLUME 19, NO. 1. A new theory of terrestrial magnetism. Another large telescope. Woodhouse and Rawson electric launches.

No. 3. Queen's new photometer. Electric transmission of power.

NOS. 4 AND 5. The Montreal electric-light convention. Long-distance power transmission at Frankfort. A Swiss electric launch.

No. 7. Recent progress in the use of electric motors. Sellers patent water-tube steam boiler. The Weston automatic engine.

No. 9. Electric welding. Electricity in the Census.

No. 16. Annual report of the naval inspector of electric lighting.

No. 24. An electrical fog bell.

The port of Ravenna, in the Adriatic, has recently been provided with a fog bell, the invention of the Abbé Ravaglia, and worked by electricity. It is situated at the end of the mole leading into the harbor, and the current is conveyed to it from a battery in the lighthouse, about a kilometer distant. The apparatus for striking the bell consists of a magneto-electric motor planted in the bell tower and connected to a mechanical puller. When the current from the battery passes through the armature of the motor, the motion of the armature is caused to turn a disk having pins projecting from its border. These pins catch on the end of a pivoted lever as the disk revolves, and by raising

one end of the lever depress the other, thereby pulling the bell chain and making the hammer strike the outer rim of the bell. A rapid series of strokes is the result, and the loud continuous note is heard for a long way. The battery employed is the constant form of Daniell, and a galvanometer is kept in the circuit to show that the current is of proper strength. A telephone circuit also enables the attendant at the lighthouse to hear the "drone" of the motor and thus know whether it is working at its proper speed. Such an apparatus is, under certain circumstances, cheaper, simpler, and more convenient than a steam siren or a bell actuated by the waves.—*London Times*.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

The handling of ingots and molds in Bessemer steel works. The Bendigo gold-field. The fuel supply of the United States. The tests and requirements of structural wrought iron and steel. Centrifugal ventilators. A new system of ore sampling.

THE JOURNAL OF THE FRANKLIN INSTITUTE.

JANUARY, 1892. The United States life-saving service. The subnormal in graphical dynamics. The port of Philadelphia. Experiments made to ascertain the specific volumes of saturated vapors of water, bisulphide of carbon, and ether; also the determination from the experimental data thus obtained of the mechanical equivalent of heat.

FEBRUARY. Bearing-metal alloys. Experiments, etc., for determination of the mechanical equivalent of heat (concluded). The specific heat of aluminium. Notes on electro-magnet machinery.

IRON AGE.

NO. 10, SEPTEMBER 3. Electrical appliances in a rolling mill (illustrated). Government tests of coil boilers (illustrated). Rapid naval construction. Foreign shipyards. The engines of the Maine.

NO. 11, SEPTEMBER 10. Steam steering gear. The armor question in 1891. Manufacture of nickelo-spiegel.

NO. 12, SEPTEMBER 17. Novel arrangement of triple-screw engines. Harrington's nickel-steel experiments. Gunpowder. Cruiser No. 9. Torpedo-boats for the navy.

NO. 13, SEPTEMBER 24. Distilling apparatus for the Maine. Petroleum in marine furnaces. The test of the Vesuvius. Vibration of torpedo-boats.

NO. 14, OCTOBER 1. A new German battle-ship.

The new German war-ship Kurfürst Friedrich Wilhelm, recently launched at Wilhelmshafen, is the first of four battle-ships now being built for the German navy. The other three are being constructed by contractors, two at Stettin and one at Kiel, but neither of them is yet launched. In fact, they are not nearly so far advanced as the one being built at the Government's works. The Kurfürst Friedrich Wilhelm is built of steel throughout, of German manufacture, and everything about the ship, excepting only the anchor-hoisting engine, is of German material. The stem is of three pieces of cast steel, of

which the middle one weighs 33,000 pounds. She is 380½ feet in length, draws 24½ feet, and is of 10,000 tons displacement. The ship has peculiar but graceful outlines, with sides having a deep tumble home amidships and a flaring bow. She is built on the longitudinal bracket system, has a double bottom and 120 water-tight compartments. The armor consists of a continuous belt of compounded steel armor 15¾ inches thick, on a teak backing. The width of the belt is nearly uniform throughout, and it is worked up against the ram, thus materially stiffening it. Her main armament consists of six 11-inch breech-loading rifles, in pairs, in three turrets; six 4.13-inch Krupp rapid-firing guns, built on an entirely new system, in broadside and protected by light armor; eight 3.43-inch guns, disposed chiefly for a raking fire ahead or astern; two rapid-firing guns in the military tops, and a number of revolving cannon and torpedo outfit. The boilers, engines and magazines are placed below a steel turtle-back protective deck, which descends below the water-line of the vessel. The other three vessels will be like this one, and each is designed for a 15 knots speed.

No. 15, October 8. The Weston automatic engine. The Belgian Mauser magazine rifle. The Victoria controllable torpedo (illustrated).

No. 16, October 15. Defending New York harbor. The new mortars, their design and manufacture (illustrated).

No. 17, October 22. Engine and helm control.

November 5. Torpedoes (illustrated).

November 12. New torpedo-boats. Armor-plate trials. The Miantonomoh.

November 19. Testing material for the Babcock and Wilcox boilers (illustrated). The Buffalo automatic injector. Adamson gun.

November 26. Engine castings in the new cruisers.

December 3. Experiments with high-tension currents. Making machine-guns. Launch of the New York.

December 10. The armor tests. Apparatus for hardening and tempering projectiles. Our achievements in naval construction.

December 17 and 24. Progress of naval construction. The safety valve. Electric reciprocating engine.

December 31. Steam boilers. Rapid-fire gun.

January 1, 1892. The whale-back. Transportation of ships. Steam boilers. Automobile torpedoes. Guns required for the navy. Smokeless powders.

January 14. The Beck steam steering gear. The Fiske electric position-finder. The U. S. cruiser Raleigh.

January 21 and 28. Torpedo-boat No. 2, U. S. N. Steam boilers. The Whitehead torpedo in Brooklyn.

February 4. Pneumatic disappearing carriage for 10-inch gun (illustrated).

H. G. D.

THE LONDON ENGINEER.

SEPTEMBER 11. Maxim on erosion in large guns. Engineers in the navy. Screw-propellers. Water-tube boilers in the United States Navy.

SEPTEMBER 18. Nordberg's automatic cut-off governor (illustrated). Steel in marine engine work. Petroleum oil engines.

SEPTEMBER 25. U. S. Cruiser No. 6. Surface condensers. Marine boilers. Marine engines in the U. S. Navy (illustrated). Practical expansion curves.

NOVEMBER 13. Armor-plate trials at Portsmouth.

NOVEMBER 20. The twin-screw steel steamer Ophir. Indian Head armor trials of plate manufactured in the United States. Accidents to English and French guns.

NOVEMBER 27. A new process for protecting iron and steel. Her Majesty's ship Nelson. Marine engines in the navy. Drying explosives in vacuum (illustrated).

DECEMBER 4. The Mills water-tube boilers.

DECEMBER 11. The resistance of steamships. High-speed gunboat. Canet quick-fire guns. Indian Head armor trials. Our monster guns.

DECEMBER 18. H. M. S. Thunderer. A new quick-firing gun. The Sims-Edison torpedo.

DECEMBER 25. Screw-propellers. Off-shore floating dock at Hamburg. Harfield's compensating steering gear (illustrated).

JANUARY 1, 1892. Engines for ships of war. War material.

JANUARY 8 AND 15. France and quick-fire guns. The navy of the United States, II. Steam engines for ships of war.

JANUARY 22. The navy of the United States, III. A French torpedo-boat.

THE MANUFACTURER.

SEPTEMBER 21, 1891. Smokeless powders.

During the course of some exhaustive and protracted experiments in Sweden the Apyrite smokeless powder has been produced, and it is reported that the new explosive has several distinct advantages over other known smokeless powders. The principal aims of the investigations were to obtain a smokeless powder based upon highly nitrated cellulose, with a low pressure of from 2200 to 2500 atmospheres, giving an initial velocity of from 630 to 650 meters, with no flame, but slight heating of the rifle, like ordinary black powder in appearance, and the products of combustion of which had an alkalescent reaction.

Apyrite is, to a large degree, unaffected by rubbing, rolling, or blows, and burns freely and without danger when ignited in even large quantities. This latter property was confirmed by an accidental ignition of some 80 kilograms of the powder in the drying room, when it was found that even some glasses which had been left in the room were quite unharmed. Its grains are prismatic in form, and bright and black in appearance, and cartridges can be charged by the ordinary appliances.

Even when heated to a high temperature in a stove Apyrite does not lose its original form, nor alter its consistency by massing together. It is almost smokeless—indeed, it excels other powders in this respect; it gives absolutely no flame, and the heating of the weapon used is exceedingly small. Experiments conducted to ascertain the comparative heating of rifle barrels have proved that 10 shots fired with nitro-glycerine powder, 15 with black powder, and 23 with Apyrite have the same effect of heating. A rifle with which 800 rounds had been fired, and which was left untouched for eight days, was then as easily cleaned as if cleaned immediately after firing. A canister containing Apyrite fired through at 50 meters range, neither exploded nor ignited for the first three shots, but at the fourth ignition took place, but the Apyrite burnt quickly without any report, and the canister was undamaged with the exception of the holes made by the bullets. In similar tests, with canisters filled with black powder and nitro-glycerine powder, an explosion occurred at the first shot, and the canisters were entirely destroyed.

In the present Swedish rifle, with a projectile weighing 14½ grains, it is proposed to use 3½ grains of Apyrite, and it is found that this gives the projectile a muzzle velocity of 640 meters, with a pressure of about 2260 atmospheres.

OCTOBER 20. A new projectile. Marine machinery. The Hall-Brown indicator.

ENGINEERING.

SEPTEMBER 4, 1891. Table showing results of firing trials with a Canet 32-centimeter 12.6-inch 66-ton gun of 40 calibers, made July, 1891, at Havre. Gun No. 11.

Number of Shot.	Weight of Shell.		Kinds of Powder.	Weight of Charge.		Muzzle Velocity.		Pressure.		Penetration in Wrought Iron.	
	Kilos.	Lbs.		Kilos.	Lbs.	Meters.	Feet.	Kilos per sq. cm.	Lbs per sq. in.	Cm.	In.
1	333	734	P. B. S.	120	264	522.8	1715	782	11,120		
2	340	749	"	160	352	610.7	2004	1221	17,361		
3	345	760	"	160	352	610.2	2002	1347	19,155		
4	344	758	"	160	353	608.3	1996	1347	19,155		
5	450	992	"	240	529	689.9	2263	2517	35,796	111.0	43.69
6	451	994	"	240	529	690	2264	2515	35,758	111.1	43.73
7	450	992	"	240	529	690	2264	2384	33,908	111.1	43.78
8	451.5	995	"	240	529	690.1	2264	2553	36,309	111.1	43.73
9	451.5	995	"	240	529	692.2	2271	2740	38,971		
10	451	994	"	255	562	717.6	2354	2865	40,760	117.9	46.42
11	451	994	B. N.	135	297	670.2	2199	2089	29,710	106.8	42.05
12	450	992	"	140	308	700.7	2299	2421	34,430	112.7	44.36
13	450.5	993	"	144	317	727.4	2386	2553	36,304	120.3	47.36

This second gun, like the first, is intended for service in a barbette turret with a Canet central loading arrangement, so that the gun can be loaded in any position. When the gun was brought from the factory to the testing ground it was mounted on its own carriage, which was also made by the Forges et Chantiers. The test comprised the firing of thirteen rounds, in one of which the charge was raised so as to increase the pressure in the gun to 39,800 pounds per square inch; both gun and mounting resisted this extreme pressure without any injury.

The most interesting feature of these trials was the extended employment of the French smokeless powder of the B. N. mark. With a charge of 144 kilograms of this powder an initial velocity of 724 meters was obtained. This was a great deal better than was given by the first gun tried some months ago.

On that occasion the maximum charge of this explosive fired was 135 kilograms, and the velocity recorded was 701.7 meters. The pressure in the gun was of course increased with the greater charge, but not sufficiently to strain the gun dangerously.

With the maximum powder charge the projectile, weighing 450 kilograms, left the gun with an energy of 1250 metric tons, corresponding to a penetrating power at the muzzle of 120.3 centimeters through wrought iron; the penetrating power of the English 110-ton gun is 120.7 centimeters. The Krupp gun of 120 tons has a corresponding penetrating energy of 126 centimeters. It would appear, therefore, from this comparison that the Canet 66-ton gun has a penetrating power equal to these enormous calibers, and the interesting fact is demonstrated by the recent trials, that a gun one-half the weight of the unwieldy and enormously costly Krupp gun can be made of practically the same efficiency at less than half the expense and with a longer term of useful life. Moreover, comparing the trials of the second with those of the first Canet 66-ton gun, it is reasonable to suppose that still better duties can be obtained, and doubtless will be obtained, with other guns of the same caliber now being made by M. Canet at Havre. Of course considerable progress is also being made with the smokeless powders, and better results than have yet been obtained may be confidently looked for. The explosive used during the recent trial had not been previously employed with such large calibers, except for the first 66-ton gun in January last, and since that date some improved methods of utilizing it had been devised.

SEPTEMBER 11. Marine engineering at Cowes (illustrated). Vibration of torpedo-boats. Turbines at Assling-Sava, Carniola (illustrated).

SEPTEMBER 18. The Morris circulating filter. The Nova Scotian steamer Boston (illustrated). Welded boilers. The Serpollet boiler. Sea-going torpedo-boat for the Brazilian navy. Marine engineering during the past decade (conclusion). The Middelgrund fortification outside Copenhagen.

SEPTEMBER 25. The Presidente Pinto (illustrated). The Serpollet boiler. Coal-burning of Atlantic liners. Compound engines.

OCTOBER 2. Steam boiler experiments, No. VII. The Swiss magazine rifle (illustrated). The spacing and construction of water-tight bulkheads.

OCTOBER 9. The Maxim automatic machine-gun (illustrated). The French navy, No. XVI.: The Richelieu. The forging press. Torpedo-boat stations and coast defense.

OCTOBER 16. The Maxim automatic machine-gun (concluded). The Thornycroft boiler in France. Weldron's range-finder.

OCTOBER 23. Armor-plate bending rolls. The British cruisers Terpsichore, Thetis, and Tribune (illustrated). The velocity of projectiles.

OCTOBER 30. Disappearing turrets for Nordenfeldt quick-firing guns (illustrated). The French navy, No. XVII.: The Sfax. A torpedo-boat boom.

NOVEMBER 6. Compound armor-plates. The Adamson gun (illustrated).

The leading feature of the weapon is the substitution for trunnions or grooves, of a spherical enlargement, which works in a correspondingly shaped socket on the carriage or mounting. By means of this ball-joint the gun can be rapidly trained, both vertically and horizontally. This feature is claimed as an advantage over the usual systems. The gun was made at the Bofors works in Sweden, and recently tested by two Swedish government artillerists. The following are the particulars: Caliber, 3.36 inches; total length, 98.43 inches; weight, 1200 pounds. Rifling: Number of grooves, 24; depth, .295 inch; width of lands, .138; twist—muzzle, 33 calibers. Weight of shell, 14.77 pounds; weight of charge (black powder), 5.51 pounds; muzzle velocity (black powder), 1920 feet; muzzle velocity (smokeless powder), 1970 feet.

With a muzzle velocity of 1984 feet per second the energy in the shot was 406 foot-tons, or 726 foot-tons per ton of gun, which was exceedingly good for a gun of only 24 calibers length.

Three series of five rounds each were fired to test the rapidity, and they occupied respectively 30 seconds, 25 seconds, and 20 seconds. At 25 degrees elevation the range was 26,250 feet, and the pressure varied between 19.8 and 21 tons per square inch. Eighty-five rounds have been fired in all with good results. The breech mechanism was of the Bofors pattern.

NOVEMBER 13. Japanese coast-guard ships. Armor-plate trials. A chronological history of electricity (continued).

NOVEMBER 20. The new Orient liner Ophir. The Franklin life-buoy. Lancashire boilers. Trials of H. M. cruiser Blake.

NOVEMBER 27. The new Orient liner Ophir. Rees magazine rifle (illustrated). The Indian Head armor trials. Fiske's electrical position-finder.

DECEMBER 4. The Atlantic liner, past, present and future. Screw propulsion with non-reversible engines. Naval *vs.* mercantile engineers. Riveted joints (illustrated).

DECEMBER 11. The United States Navy exhibit at Chicago (illustrated). Efficiency of centrifugal pumps.

DECEMBER 18. Quick-firing guns. The form of ships' hulls. Additions to the navy in 1891. Marshall and Wigram's balanced slide-valve.

DECEMBER 25. Canet *vs.* Krupp guns. French sea-going torpedo-boats. The Benardos system of electric welding. Nickel-steel armor trials. Water-gauge fittings for steam boilers.

JANUARY 1, 1892. Ship-building in the United Kingdom in 1891. The first-class cruiser Edgar. Canet *vs.* Krupp guns (continued).

JANUARY 8. The Marque screw propeller. High-speed engine and dynamo. Trial of a steam turbine dynamo. Chronological history of electricity (continued).

JANUARY 15. Canet *vs.* Krupp guns. The first class-cruisers .r and Hawke (illustrated).

DIMENSIONS, ETC., OF SEVERAL FAST CRUISERS.

	H. M. S. Edgar.	H. M. S. Blake.	H. M. S. Australia.
Length	360 ft.	375 ft.	300 ft.
Breadth	60 ft.	65 ft.	56 ft.
Draught (mean)	23 ft. 9 in.	25 ft. 9 in.	22 ft. 6 in.
Displacement	7350	9000	5600
Indicated horse-power (mean)	12,463	14,535	8500
Speed (knots)	20.97	19.3	18.5
Coal on designed draught (tons)	850	1500	900
Endurance at 10 knots	10,000	15,000	8000
Protective deck slopes	5 in. and 2 in.	6 in. and 4½ in.	Belt
Flats	2½ in.	3 in.	..
Armament	2 9.2-in. B. L.; 10 6-in. R. F.; 16 6-pdrs.; 3 3-pdrs.; 8 machine.	2 9.2-in. B. L.; 10 6-in. R. F.; 16 3-pdrs.	2 9.2-in. B. L.; 10 6-in.; 16 R. F.; 7 machine.

	U. S. New York.	Commerce Destroyer (U. S.)	French Cécille.
Length	380 ft.	412 ft.	378 ft.
Breadth	64 ft. 10 in.	58 ft.	49 ft. 3 in.
Draught (mean)	23 ft. 3½ in.	24 ft.	19 ft. 9 in.
Displacement	8150	7475	5766
Indicated horse-power (mean)	16,500	21,000	9600
Speed (knots)	20	22	19
Coal on designed draught (tons)	..	750	...
Endurance at 10 knots	..	9800	..
Protective deck slopes	6 in. and 3 in.	4 in.	..
Flats	3 in.	2½ in.	..
Armament	6 8-in. B. L.; 12 4-in. R. F.; 8 6-pdrs.; 4 1-pdrs.; 4 Gatlings.	4 6-in B. L.; 12 4-in R. F.; 16 6-pdrs.; 8 1-pdrs.; 4 Gatlings.	6 6.3-in. 5-ton B. L. R.; 10 5.49-in. 3-ton B.L.R.; 3 Q.F.; 10 machine.

Tests of single cylinder, compound and triple-expansion cylinders of same type. Chronological history of electricity (continued).

JANUARY 22. Canet *vs.* Krupp guns (continued). Torpedo-boat for Victoria (illustrated). The want of torpedo-boats. A new French torpedo-boat. H. G. D.

THE STEAMSHIP.

NOVEMBER, 1891. Screw propellers.

Commenting on the results of the discussions in the columns of the leading engineering journals, extending over a considerable period of time, as to the best design of propeller to suit any given vessel, Mr. Winterburn states that the results are practically *nil*. After a wordy warfare, in which some of the best-known names connected with the English technical colleges and many able designers of ships have figured, it appears that the question is in precisely the same condition as before, and the most suitable propeller for any given design of hull still remains a result of trial and error. Startling arrays

of figures have been published, showing how the stern lines affect the closing in of the wave made by the vessel; the angle of incidence where each particle of water strikes its corresponding portion of the blade, the angle at which it is projected off, and the resultant deduced therefrom, by which the most suitable blade can be designed and its velocity ascertained; full, straight, and hollow lines of hull have each their adherents; in fact, every possible style of vessel and shape of propeller have their partisans, who have fought for their particular hobbies; yet nothing has been evolved which will convince an unbiased mind that any given propeller is the best possible for the vessel for which it is intended.

The dynamics involved in the lines and speed of ships. Steam-engine efficiency. Screw propulsion with non-reversible engines.

A description, with illustrations, of Beaumont's method of screw propulsion, with feathering bladed screw, by means of which the engines always move in the same direction.

By means of this invention, as Mr. Beaumont points out in his paper, it is possible to achieve several ends which are of great importance, some of which may be enumerated as follows: (1) the propulsion of ships by means of screws which always rotate in the same direction and may be actuated by non-reversible engines and screw shafts; (2) the simplification of marine engines, by dispensing with all the parts used for making the engines reversible; (3) the complete and quick reversal of the direction of propulsion without any of the heavy stress tending to rupture of screw shaft and couplings; (4) the easy adjustment of the pitch while the engines are running.

DECEMBER. A comparison between double and triple-expansion engines. Tests of wrought-iron lap-welded main steam-pipes for marine boilers.

Detailed results of a test made in Glasgow under the supervision of the officers of the Board of Trade and Lloyds.

JANUARY, 1892. Improved boiler flue flange drilling machine. The relation of engineering and naval instruction. J. K. B.

THE RAILROAD AND ENGINEERING JOURNAL.

JANUARY, 1892. Notes on combustion. Tests of a compound locomotive. Progress in the United States navy. The trials of American made armor plate. Foreign naval notes.

FEBRUARY. A thermo-electric method of studying cylinder condensation. Army ordnance notes. Recent armor trials.

J. K. B.

INSTITUTION OF MECHANICAL ENGINEERS.

A review of marine engineering during the past decade.

In this paper Mr. Blechyden starts with the introduction of the triple expansion engine, and gives a general resumé of the changes consequent upon a higher boiler pressure and increased expansion; taking them up under the following heads: 1. Modifications in the engine; 2. The valve gear and valves; 3. The pumps; 4. The boilers, the change in material used and the advance in application of tools to boiler-making, corrugated, ribbed and spiral flues; 5. Forced draught, the methods in use and their economy; 6. Steam pipes, feed-heating and the auxiliary supply of fresh water; 7. Screw propellers and the weight of machinery per H.P. J. K. B.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIP-BUILDERS.

VOLUME VII., 1891. Increased boiler pressure and increased piston speed for marine engines.

The object of the author in this paper was to raise a few questions as to the advisability of increasing the working pressure and the piston speed, and to consider what type of engine and boiler would best suit these new conditions.

Screw propeller.

A paper read by Mr. Blechyden, on the influence of the relative dimensions and proportions of the screw propeller on the vessel's performance, with a comparison of the trial data of certain vessels, and of the relation of the dimensions of the screws to the sizes of the vessels they were used to propel. Also a method of calculating the power which can be developed upon a screw of given dimensions, based on the model experiments, and by a series of examples is shown the relation of the calculated powers to those obtained on trial.

The strength of short flat-ended cylindrical boilers. Water-gauge fittings for steam boilers. Electrical engineering. Results of experiments on the strength of boilers. The unsinkability of cargo-carrying vessels. J. K. B.

TRANSACTIONS AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

VOLUME XII., 1891. Chimney draught, facts and theories (Thurston). Special experiments with lubricants (Denton). Authorities on the steam jacket: facts and current opinions (Thurston). Tests of a triple-expansion engine (Henthorn). A belt dynamometer (Alden). Steel castings (Gault). Notes regarding calorimeters (Carpenter). The application of Hirn's analysis to the multiple expansion engine (Peabody). Mechanical stokers (Roxey). Manganese steel (Howe). The effect of a steam jacket upon cylinder condensation (Bird). A belt dynamometer (Watt). The report of committee on a standard method for conducting the duty trials of pumping engines. Steam-engine efficiencies (Thurston).

J. K. B.

TRANSACTIONS AMERICAN SOCIETY OF MINING ENGINEERS.

VOLUME XIX., 1891. Explosions from unknown causes. The protection of iron and steel ships against foundering, from injury to their shells. The development of the marine engine and the progress made in marine engineering during the past fifteen years. On welding by electricity. The inspection of materials of construction in the United States. Fuel gas and some of its applications. Aluminium steel. Spirally welded steel tubes. Notes on the Bessemer process. International standards for the analysis of iron and steel. The iron ores of the United States. Cast-iron tools for cutting metal. The progress of German practice in the metallurgy of iron and steel.

J. K. B.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

NOVEMBER, 1891. Fan-blowers. Theory of the centrifugal pump. Some new alloys. Electric lighting of ships. Radial valve gears. Speed curves of ships building for the U. S. Navy. Rational lubrication of marine engines. Spontaneous ignition of coal. Speed trials. Notes on superheating steam, the Harvey process of hardening steel, and the efficiency of steam separators. J. K. B.

CASSIER'S MAGAZINE.

DECEMBER, 1891. The technical schools of America. The influence of steam jackets. Water rams in steam pipes. Electric power distribution. Mechanical refrigeration. J. K. B.

THE STEVENS INDICATOR.

OCTOBER, 1891. Lecture notes on steam hammers and hydraulic forging and riveting. The performance of a steam reaction wheel. The relative merits of various steam tables. Oils used in lubrication. J. K. B.

INSTITUTION OF MECHANICAL ENGINEERS.

APRIL, 1891. Research committee on marine engine trials: Report upon trials of the S. S. Iona, by Prof. Kennedy. J. K. B.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

SEPTEMBER, 1891. Notes on the present position of the question of transmission of power.

A paper containing a record of what has been done in the transmission of power by steam, compressed air, hydraulic power, ropes, and by electrical transmission. J. K. B.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

VOLUME XXV., OCTOBER, 1891. Screw steamship and tow-barge efficiency. On the Straits of Juan de Fuca, Puget Sound, and government improvements on the Pacific Coast. Some recent experiments with dynamite on an ocean bar. J. K. B.

LE YACHT.

JULY 11, 1891. French naval manœuvres. Mobilization of 1891.

The article gives, with a complete list of the vessels participating in the third series of the manœuvres, the general dispositions taken to serve as a guide to the belligerents. The theme is a simple one. A squadron, A, sails north from Gibraltar between the Balearic Isles and the Spanish coast. Another squadron, B, cruising about to protect the coasts of France and Corsica, is informed by telegraph that the squadron A has just rounded Cape Gate, and thereupon advances to meet and intercept the latter between Majorca and Barcelona. The advantage of speed is on the side of A, while B has that of number and fighting power.

The armored battleships may not develop more than 8.5-tenths of the maximum number of revolutions exhibited in their trials; light vessels may develop 9-tenths of their power, with forced draft. Torpedo-boats are at liberty to use all their speed.

The fighting power of each vessel, with the exception of torpedo-boats, is determined by a numeric coefficient. In the case of the vessels of squadron A succeeding in reaching the coasts of France or Corsica, they must remain near their objective points of attack for six hours at least, three of which of daytime, and be superior in force to the land and floating defenses confronting them, before said points are considered subdued.

In order to accomplish this, a numeric coefficient of warlike power is given to the land defenses of the following cities: Toulon, Marseilles, Villefranche, Nice, Ajaccio, Port Vendres, Cette, Antibes, Bastia; the other seaports being supposed defenseless. The roads of Hyères remain neutral. Hostilities shall cease at the latest at eight o'clock in the morning of July 11. After that hour all the vessels, even those attached to the defenses of the sectors, will rendezvous in the roads of Hyères.

Rules: Vessels may, when so authorized or ordered by their respective commanders-in-chief, screen their running lights, so arranged that they may be exhibited instantaneously. When two hostile vessels or forces shall approach one another at a distance equal or inferior to 2000 meters they will invariably be considered as in action; the doors of the water-tight compartments must be closed, and at night the running lights as well as station lights must show on all the vessels with the exception of torpedo-boats.

The combat shall be supposed ended (1) as soon as the vessels have steamed past each other in opposite directions; (2) when both adversaries being situated end on, have remained for at least twenty minutes at a distance of 2000 meters from one another.

Will be considered as having taken part in an action the following vessels only: (1) Vessels acting singly that have kept within 2000 meters of the enemy for twenty minutes, or have steamed past on opposite tacks at a distance of less than 1000 meters; (2) Vessels belonging to a group formed in tactical order with intervals and distances below 1000 meters, when any one of the vessels forming part of the group will have found itself in the position described in the first part of the paragraph.

In the case of an engagement, the coefficient of the fighting power of all vessels considered as having been in action shall be added together on each side, after deducting half the coefficient of those that have been torpedoed during the combat. The results shall be determined by the following rules: In case of the sums of the coefficients being equal, the combat will be considered undecided; in fact, a drawn battle. The hostile forces are then to separate 50 miles in daytime and 30 at night, both steaming back half the distance they came from, the use of scouts not being allowed. They will then recover their freedom of action.

In case of the sums being unequal: If the two sums of coefficients are in a ratio of 3 to 2, the weakest side shall be considered as destroyed and will repair to the islands of Hyères. If the ratio of the two sums be equal or inferior to 3 to 2, the weakest side shall lose one of its strongest fighting units, which then steams back to Hyères. The other vessels separate as in the case of a drawn battle.

Torpedo-boats may simulate attacks, taking care in case of an action in columns on contrary tacks not to deviate more than 200 meters from the line of file of their own squadron. Torpedo-boats having exhausted their supply of torpedoes may not simulate other attacks before receiving fresh supplies from the battle-ships; the renewal of supplies will be merely feigned. Fighting ships, with the exception of torpedo-destroyers, may be torpedoed by torpedo-cruisers, dispatch torpedo-boats, and torpedo-boats. To accomplish this, two light vessels must be in a position to fire their torpedoes at the same

vessel within a distance of 500 m. during an interval of thirty minutes in daytime or two hours at night, provided they remain no longer than ninety minutes under the fire of the quick-firing guns of the assailed vessel. A ship torpedoed four times from the beginning of hostilities will be considered *hors de combat* and will return to Hyères. After each engagement the commander-in-chief, and in his absence the senior captain, embarked as one of umpires, will decide and signal the results of the affair, applying the foregoing rules.

The auxiliary petroleum motors of Messrs. Forest and Gallice. Description of recent torpedo-destroyers (contre-torpilleurs). First-class cruiser Jean Bart.

AUGUST 8. The armor-clad division of the North. Squadrons' scouts. In a conning tower; or how I took H. M. S. Majestic into action, translated from the English, is an article on the model of the "Battle of Port Saïd" and other imaginary combats.

DECEMBER 19. Comparison between the Canet and the Krupp guns.

The author of this article, taking to task the Dresden "Internationale Revue," pointing out a great many inaccuracies, and reviewing the fact in all its aspects, comes to the conclusion that the Canet gun is superior to any gun now in existence.

The American cutter yacht Gloriana. J. L.

JANUARY 2, 1892. The war navies of 1891.

An article in which E. Weyl reviews the principal naval events of the past year.

JANUARY 9. The war navies of 1891 (continued). Technical naval association: a note touching the stability of torpedo-boats in the swell of the sea, by M. Ferrand. The Shipping World Year-Book for 1892.

JANUARY 16. The necessity for war fleets (E. Weyl).

JANUARY 23. The armored battle-ships of the Triple Alliance: the German armor-clads.

REVISTA TECNOLÓGICO INDUSTRIAL.

DECEMBER, 1891. An appeal from the "Material para ferrocoriles" Company of Barcelona, to be awarded the contract for furnishing the 70 postal cars advertised for by the Spanish government. A history of flour-mills and bakeries from the earliest ages to this day (ended).

BOLETIN DEL CENTRO NAVAL, BUENOS AIRES.

SEPTEMBER, 1891. A public reception tendered to the President of the Republic by the "Centro Naval" Club. The President on board the new battle-ship, 25 de Mayo. Review of the whole fleet in the roads, on Sept. 3, 1891.

REVUE DU CERCLE MILITAIRE.

DECEMBER 20, 1891. Notes on the German army, by an English officer (ended). Utilization of long ranges (rifle model, 1886). Notes on the Chinese army (continued).

DECEMBER 27. How does the question of the small-caliber gun stand? Notes on the Chinese army (ended). Utilization of long ranges, etc. (ended).

JANUARY 3, 1892. Electric search-lights in the army; experiments made in different countries. Projected strategic railway on the Rhine.

JANUARY 17. Field-howitzers in the Russian army (ended). The Franco-Italian frontier (with a separate map), (ended).

JANUARY 24. The German cavalry as viewed from the standpoint of an Englishman. J. L.

THE WESTERN SOLDIER.

BULLETIN OF THE AMERICAN IRON AND STEEL ASSOCIATION.

TEKNISK TIDSKRIFT.

TRANSACTIONS AND PROCEEDINGS OF THE GEOGRAPHICAL SOCIETY OF THE PACIFIC

VOLUME II., NO. 1. Humboldt Bay, by Prof. Geo. Davidson. Geographical and ethnological notes on Alaska, by Ivan Vetroff. Corea, the hermit kingdom, by J. T. Scott.

OUTING, a Monthly Magazine.

THE COLLIERY ENGINEER.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES Volume III., Part 1.

MÉMOIRES ET COMPTE RENDU DES TRAVAUX DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

REVISTA TECNOLOGICO INDUSTRIAL.

BULLETIN OF THE AMERICAN GEOGRAPHICAL SOCIETY, Dec. 31, 1891.

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY, Volume XXIX., No. 136.

BOOKS AND PERIODICALS RECEIVED.

GOLDTHWAITE'S GEOGRAPHICAL MAGAZINE.

MINERALS, a Monthly Magazine.

BEITRÄGE ZUR GEOGRAPHIE DES FESTEN WASSERS. Published by the Verein für Erdkunde, Leipzig.

REPORT ON UNIFORM SYSTEM FOR SPELLING FOREIGN GEOGRAPHICAL NAMES.

POSTAL SAVINGS BANKS; AN ARGUMENT IN THEIR FAVOR BY THE POSTMASTER-GENERAL. Annual report of the Postmaster-General of the United States, for the fiscal year ending June 30, 1891.

TABLES CONDENSÉES POUR LE CALCUL RAPIDE DU POINT OBSERVÉ, par E. Serres, Lieutenant de Vaisseau.

ANNUAL REPORT OF THE LIEUTENANT-COMMANDER FIRST BATTALION NAVAL RESERVE ARTILLERY OF THE STATE OF NEW YORK.

ANNUAL REPORT OF THE INSPECTOR-GENERAL FOR THE YEAR 1891.

REPORT OF THE BOARD OF ENGINEER OFFICERS OF THE U. S. NAVY ON WARD'S WATER TUBE MARINE BOILER.

CENSUS BULLETINS.

ALMANACH DER KRIEGS FLOTTEN, 1892.

TRANSLATORS AND REVIEWERS.

Lieutenant R. R. INGERSOLL, Lieutenant H. C. GEARING,
Professor JULES LEROUX, P. Asst. Engineer J. K. BARTON,
Ensign H. G. DRESEL.

ANNUAL REPORT OF THE SEC. AND TREAS. OF THE U. S. NAVAL INSTITUTE.

To the Officers and Members of the Institute.

Gentlemen:—I have the honor to submit the following report for the year ending December 31, 1891:

ITEMIZED CASH STATEMENT.

Receipts during Year 1891.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Advertisements	$287 50	$100 00	$150 00	$69 90	$607 40
Dues	1225 70	490 00	252 56	377 37	2345 63
Sales	1238 94	40 65	181 04	341 09	1801 72
Subscriptions	228 90	351 65	193 25	224 85	998 65
Life-membership fees	120 00	30 00	....	60 00	210 00
Binding, extra	18 65	12 18	3 00	8 35	42 18
Interest on deposits	70 97	9 00	80 88	9 00	169 85
To stamps and premium, money orders	59	3 44	03	25	4 31
Registry charges and alterations, No. 56	9 58	....	....	....	9 58
Overcharges, No. 58	....	....	40 79	....	40 79
Printing half tones	....	....	175 37	45 44	220 81
Credit Hudson's list	....	....	1 00	....	1 00
Freight and hauling	....	....	....	1 02	1 02
Totals	$3200 83	$1036 92	$1077 92	$1137 27	$6452 94

Expenditures during Year 1891.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Printing and binding publications	$1564 52	$520 93	$800 54	$1450 43	$4336 42
Extra reprinting	...	....	164 25	....	164 25
Extra binding	1 30	18 65	9 30	....	29 25
Freight and expressage	14 59	18 08	12 28	12 65	57 60
Postage	55 64	58 32	25 05	32 05	171 06
Telegrams	1 36	29	25	1 17	3 07
Stationery	11 23	38 70	....	7 25	57 18
Office expenses	1 25	1 97	1 75	83	5 80
Purchase of bonds	242 25	....	....	....	242 25

EXPENDITURES DURING YEAR 1891.—*Continued.*

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Purchase of back numbers.	$7 12	....	....	$5 25	$12 37
Purchase of seal press....	5 00	....	....	....	5 00
Subscription Army and Navy Register.........	3 00	....	....	....	3 00
Secretary...............	90 00	$90 00	$90 00	90 00	360 00
Secretary's salary Dec. '90.	30 00	....	....	....	30 00
Clerk..................	120 00	120 00	120 00	120 00	480 00
Annual prize............	100 00	....	....	....	100 00
Gold medal and engraving	18 00	....	....	....	18 00
Expenses Newport Branch	50	....	....	....	50
Expenses Washington Branch...............	2 45	....	....	1 55	4 00
Half profits, No. 34.......	7 59	....	....	....	7 59
Refunding sight draft.....	....	....	3 00	....	3 00
Insurance on stock.......	....	...	....	12 50	12 50
Electrotypes No. 60......	....	....	....	18 00	18 00
Totals..............	$2275 80	$866 94	$1226 42	$1751 68	$6120 84

SUMMARY.

Balance of cash unexpended for the year 1890......................	$1717.92
Total receipts for 1891..	6452.94
Total available cash, 1891	$8170.86
Total expenditures for 1891....................................	6120.84
Cash unexpended, January 1, 1892	$2050.02
Cash held to credit of Reserve Fund............................	127.19
True balance of cash on hand, January 1, 1892...............	$1922.83
Bills receivable for sales of No. 60................................	80.00
" " " dues, 1891	522.00
" " " back dues...	376.00
" " " binding..	26.00
" " " subscriptions	104.00
Institute property, including back numbers on hand.................	3515.00
Total assets..	$6545.83

It may be noted that during the year 1891 one extra number of the Proceedings, No. 56, was published, and the printing of six numbers, 55 to 60 inclusive, was paid for, leaving no outstanding bills.

RESERVE FUND.

List of bonds deposited for safe-keeping in the Farmers National Bank of Annapolis, Md.:

United States 4 per cent registered bonds	$900.00
District of Columbia 3.65 per cent registered bonds	2000.00
" " " " coupon "	350.00
	$3250.00
Cash in bank uninvested	127.19
Total Reserve Fund	$3377.19
Annual interest on bonds	121.77
Number of new life members	4

During the year four District of Columbia bonds, 3.65 per cent, face value $200, were purchased for $242.25.

Membership.

The membership of the Institute to date, January 1, 1892, is as follows: Honorary members, 6; life members, 104; regular members, 560; associate members, 180; total number of members, 850.

During the year 1891 the Institute lost 32 members by resignation and 11 by death. 63 new members' names were added to the rolls; viz. 39 regular, 20 associate, and 4 life members; 3 regular members became life members.

Members Deceased since January 20, 1891.

Life Members.

Floyd, Richard, July, 1891.
Paul, A. G., Lieutenant, U. S. N., May 13, 1891
Watrous, C., August, 1891.

Regular Members.

Carter, S. P., Rear-Admiral, U. S. N., May, 1891.
McGregor, C., Commander, U. S. N., July, 1891.
McLane, A., December 16, 1891.
Norris, G. A., Lieutenant-Commander, U. S. N., July, 1891.
Rodgers, C. R. P., Rear-Admiral, U. S. N., January 8, 1891.
Yates, A. R., Captain, U. S. N., November 18, 1891.

Associate Members.

Campbell, J. B., Captain 4th Artillery, U. S. A., August 28, 1891
Falsen, C. M., Lieutenant, N. Navy, 1891.

Circulation of the Proceedings during the Year 1891.

	First Quarter. No. 56.	No. 57.	Second Quarter. No. 58.	Third Quarter. No. 59.	Fourth Quarter. No. 60.	Tota .
Members	872	872	869	866	863	4342
Subscriptions	251	251	251	252	154	1159
Exchanges	102	102	100	100	100	504
Sales	1141	8	4	1	602	1756
Sale of back numbers	66		13	115	16	210
	2432	1233	1237	1334	1735	7971

Corresponding Societies and Exchanges.

United States.

American Academy of Arts and Sciences, Boston, Mass.
American Chemical Journal, Baltimore, Md.
American Geographical Society, New York, N. Y.
American Institute of Mining Engineers, New York, N. Y.
American Iron and Steel Association, Philadelphia, Penna.
American Metrological Society, Columbia School of Mines, New York, N. Y.
American Philosophical Society, Philadelphia, Penna.
American Society of Civil Engineers, New York, N. Y.
American Society of Mechanical Engineers, New York, N. Y.
American Society of Naval Engineers, Navy Department, Washington, D. C.
California Academy of Sciences, San Francisco, Cal.
Cassier's Magazine, New York, N. Y.
Colliery Engineer, Scranton, Penna.
Connecticut Academy of Arts and Sciences, New Haven, Conn.
Electrical Review, New York, N. Y.
Elliott Society, Charleston, S. C.
Franklin Institute, Philadelphia, Penna.
Geographical Society of the Pacific, San Francisco, Cal.
Journal of the Association of Engineering Societies, St. Louis, Mo.
Journal, The Railroad and Engineering, New York, N. Y.
Journal of the U. S. Cavalry Association.
Lend-a-Hand, Boston, Mass.
Mechanics, Philadelphia, Penna.
Military Service Institute of the United States, Governor's Island, N. Y.
School of Mines Quarterly, New York, N. Y.
Smithsonian Institute, Washington, D. C.
Technical Society of the Pacific Coast, San Francisco, Cal.
The Engineer, New York, N. Y.
The Iron Age, New York, N. Y.
The Railroad Gazette, New York, N. Y.

The Stevens Indicator, Hoboken, N. J.
The United Service, Philadelphia, Penna.
Wagner Free Institute of Sciences.

FOREIGN.

Annalen der Hydrographie, Berlin, W., Prussia.
Asociacion de Ingenieros Industriales, Spain.
Boletin do Club Naval, Brazil.
Boletin del Centro Naval, South America.
Canadian Institute, Toronto, Canada.
Canadian Society of Civil Engineers, Montreal, Canada.
Deutsche Heeres Zeitung, Berlin, Germany.
Engineering, London, England.
Giornale d'Artiglieria e Genio, Rome, Italy.
Institute of Mining and Mechanical Engineers, London, England.
Institution of Civil Engineers, London, England.
Institution of Mechanical Engineers, London, England.
Journal de la Marine. Le Yacht, Paris, France.
Kongl. Orlogsmarma-Sallskapet, Carlskrona, Sweden.
Manufacturer and Inventor, London, England.
Mittheilungen aus dem Gebiete des Seewesens, Pola, Austria.
Mittheilungen des Vereins für Erdkunde zu Leipzig, Austria.
Mittler & Sohn, Berlin, Germany.
Norsk Tidsskrift for Sovaesen, Horten, Norway.
North-East Coast Institution of Engineers and Shipbuilders, England.
Revista de la Union Militar, Argentine Republic.
Revista Maritima Brazileira, Rio de Janeiro, Brazil.
Revista Militar, Santiago, Chili.
Revue du Cercle Militaire, France.
Revue Maritime et Coloniale, Paris, France.
Rivista Marittima, Rome, Italy.
Royal Artillery Institution, England.
Royal United Service Institution, England.
Société des Ingenieurs Civils, Paris, France.
Teknisk Tidskrift, Stockholm, Sweden.
The Engineer, London, England.
The Steamship, Leith, Scotland.
United Service Gazette, London, England.
United Service Institute, Sidney, New South Wales.

PUBLICATIONS ON HAND.

The Institute had on hand at the end of the year the following copies of back numbers of its Proceedings:

	Plain copies.	Bound copies.		Plain copies.	Bound copies.
Whole No. 1	197	...	Whole No. 31	31	67
2	199	...	32	1	173
3	58	...	33	13	162
4	148	...	34	105	51
5	120	...	35	104	66
6	3	...	36	259	24
7	8	...	37	165	20
8	33	...	38	245	3
9	40	...	39	140	2
10	8	...	40	627	111
11	211	...	41	253	20
12	54	...	42	127	15
13	4	...	43	290	4
14	5	...	44	279	11
15	3	...	45	214	18
16	218	...	46	221	18
17	1	...	47	197	18
18	89	...	48	168	18
19	108	...	49	217	17
20	124	...	50	175	17
21	228	...	51	229	18
22	272	...	52	195	18
23	172	...	53	547	35
24	196	...	54	210	8
25	1137	42	55	222	17
26	200	27	56	592	53
27	288	27	57	165	21
28	3	16	58	204	22
29	220	27	59	169	23
30	250	4	60	1126	22

2 Vol. X., Part 1, bound in half morocco.
1 " " " 2, " " " "
1 " XIII.," 2, " " " "
1 No. 34, bound in half morocco.
4 " " " " calf.
1 " " " full sheep.
10 No. 60, " " flexible leather.
39 " " " " cloth.

Very respectfully,

H. G. Dresel,

Secretary and Treasurer.

Annapolis, Md., *Jan.* 1, 1892.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1893.

A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the Prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1893. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

H. G. DRESEL,
Ensign, U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *March* 15, 1892.

NOTICE.

The U. S. Naval Institute was established in 1873, having for its object the advancement of professional and scientific knowledge in the Navy. It now enters upon its twentieth year of existence, trusting as heretofore for its support to the officers and friends of the Navy. The members of the Board of Control cordially invite the co-operation and aid of their brother officers and of others interested in the Navy, in furtherance of the aims of the Institute, by the contribution of papers and communications upon subjects of interest to the naval profession, as well as by personal support and influence.

On the subject of membership the Constitution reads as follows:

ARTICLE VII.

SEC. 1. The Institute shall consist of regular, life, honorary, and associate members.

SEC. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fee to the Secretary and Treasurer, or to the Corresponding Secretary of a Branch. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

SEC. 3. The Prize Essayist of each year shall be a life member without payment of fee.

SEC. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

SEC. 5. Associate members shall be elected from officers of the Army, Revenue Marine, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

SEC. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

SEC. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control, and, if their report be favorable, the Secretary and Treasurer shall make known the result at the next meeting of the Institute, and a vote shall then be taken, a majority of votes cast by members present electing.

The Proceedings are published quarterly, and may be obtained by non-members upon application to the Secretary and Treasurer at Annapolis, Md. Inventors of articles connected with the naval profession will be afforded an opportunity of exhibiting and explaining their inventions. A description of such inventions as may be deemed, by the Board of Control, of use to the service, will be published in the Proceedings.

Single copies of the Proceedings, $1.00. Back numbers and complete sets can be obtained by applying to the Secretary and Treasurer, Annapolis, Md.

Annual subscription for non-members, $3.50. Annual dues for members and associate-members, $3.00. Life membership fee, $30.00.

All letters should be addressed to Secretary and Treasurer, U. S. Naval Institute, Annapolis, Md., and all checks, drafts and money orders should be made payable to his order, without using the name of that officer.